Atmosphere Monitoring

Aerosol activities at ECMWF

Zak Kipling and Mel Ades

With thanks to Angela Benedetti, Alessio Bozzo, Julie Letertre-Danczak, Luke Jones, Samuel Remy, Johannes Flemming, Antje Inness, Mark Parrington and Richard Engelen

Atmosphere
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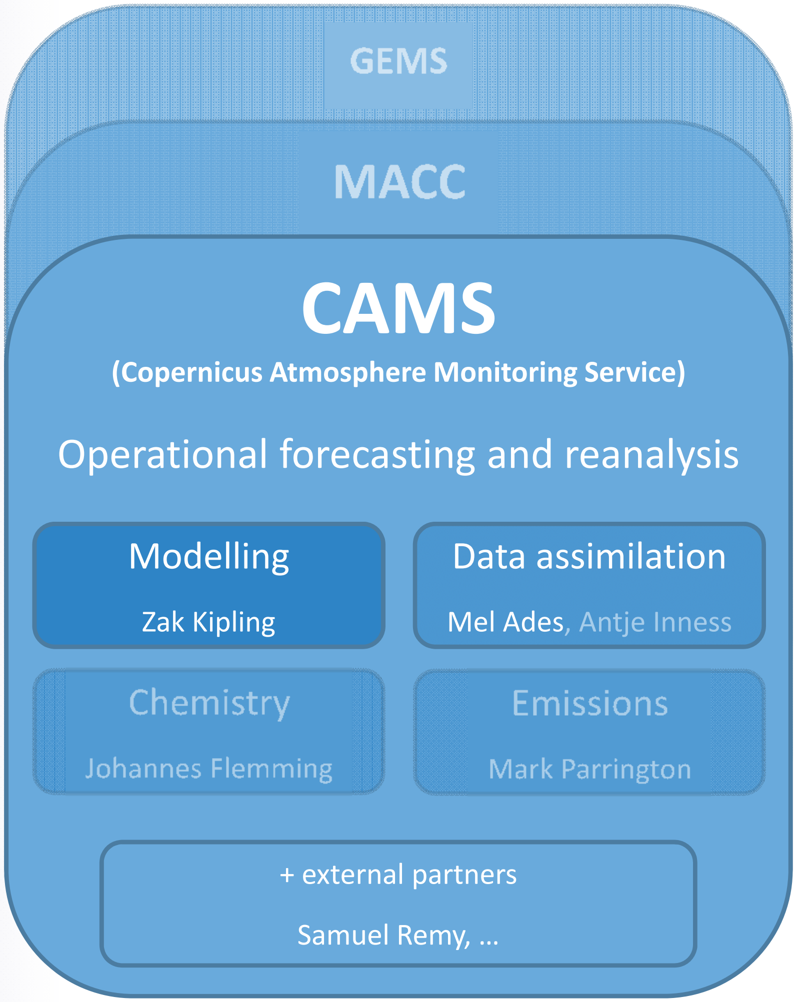
Overview of aerosol activities at ECMWF



GEMS

MACC

CAMS

(Copernicus Atmosphere Monitoring Service)

Operational forecasting and reanalysis

Modelling

Zak Kipling

Data assimilation

Mel Ades, Antje Inness

Chemistry

Johannes Flemming

Emissions

Mark Parrington

+ external partners

Samuel Remy, …

Aerosols in monthly and seasonal forecasting

Angela Benedetti *(Wednesday)*

Aerosols and radiative transfer

Alessio Bozzo *(Tuesday)*
Marco Matricardi *(Tuesday)*

Assimilation of lidar and radiances

Angela Benedetti, Julie Letertre-Danczak

Radiative impact of aerosols in NWP

Samuel Remy (Wednesday)

Verification against AERONET, GAW, ACTRIS

Luke Jones, Julie Letertre-Danczak

ECMWF Copernicus Europe's eyes on Earth European Commission

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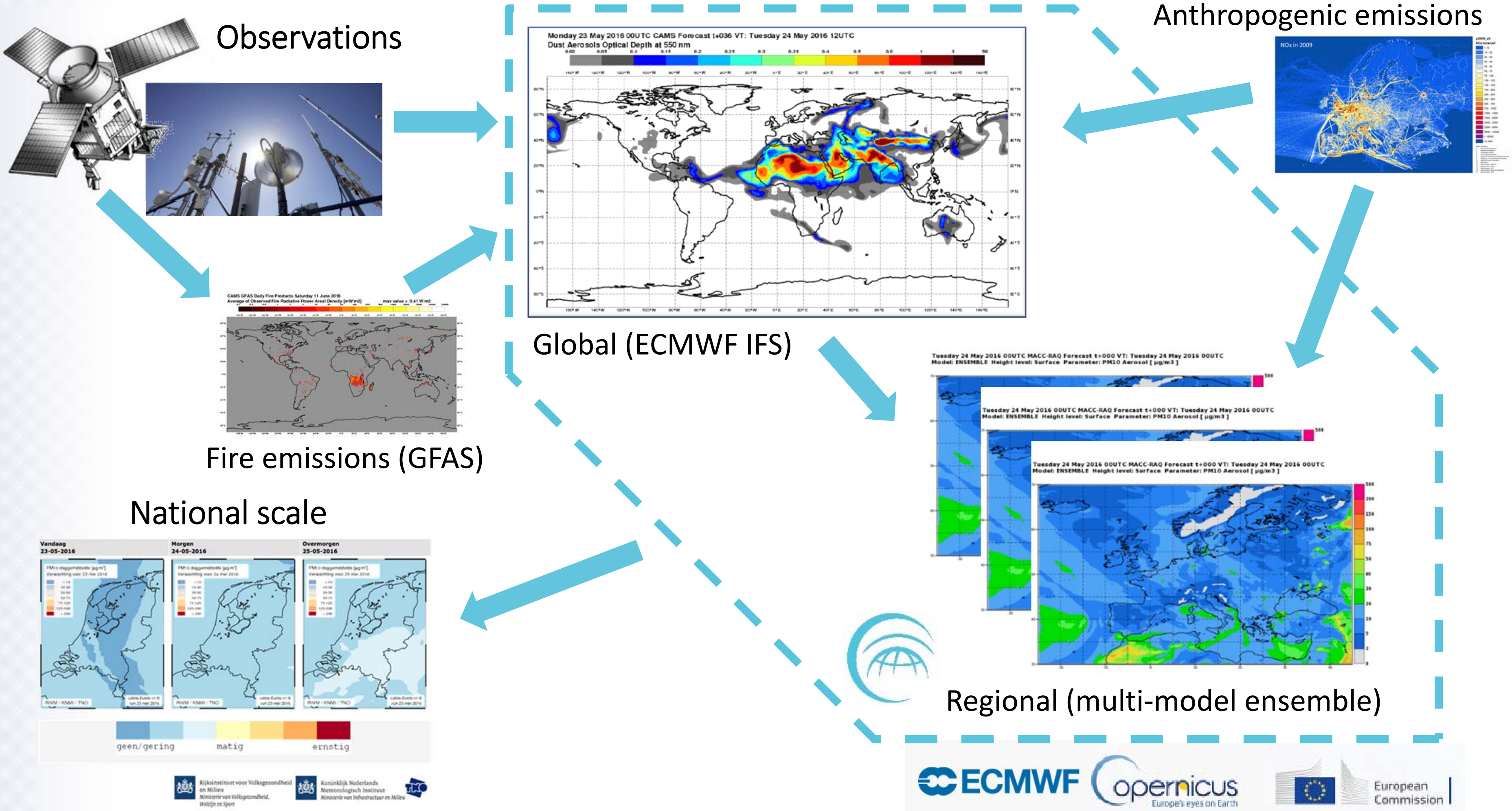
The CAMS system

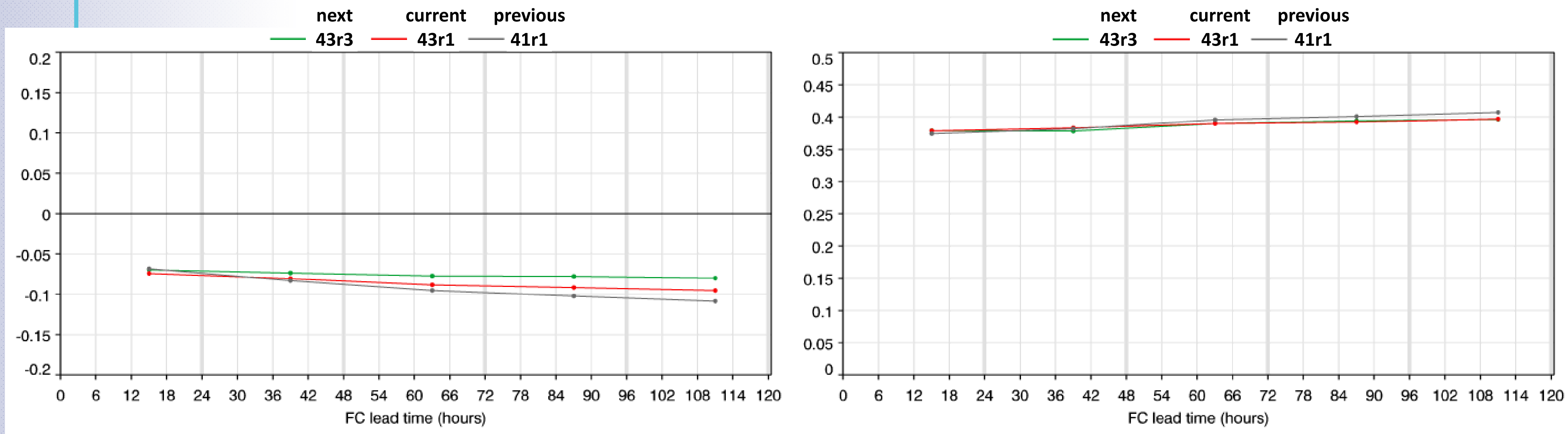


ECMWF
Copernicus
Europe's eyes on Earth
European Commission

Evolution of the CAMS global system

Atmosphere Monitoring

500nm AOD vs Aeronet (L1.5)



Bias

RMSE

25 Oct 2016 – 24 Jan 2017

AERONET verification tool: *Luke Jones*

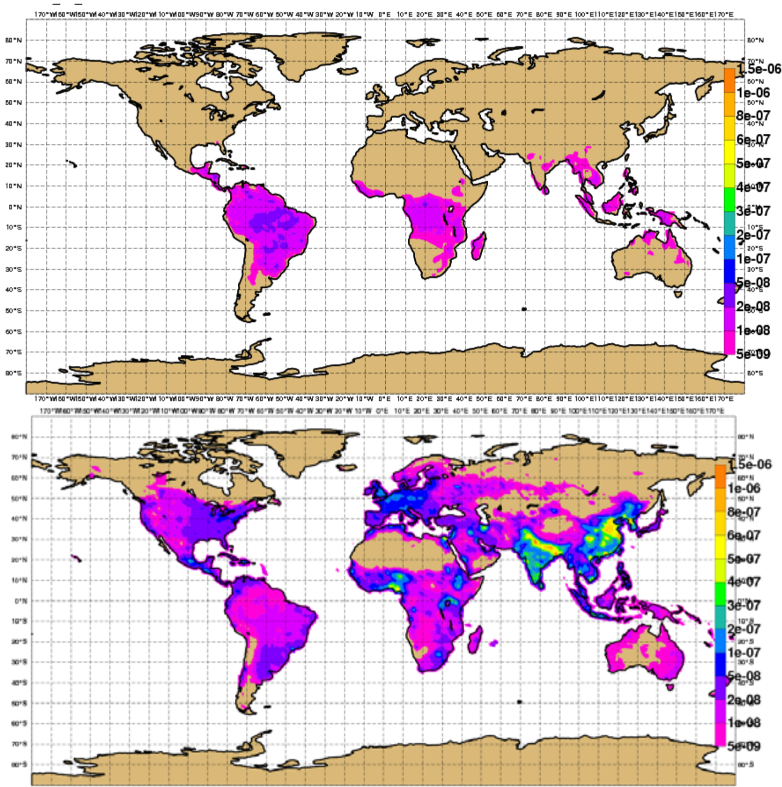
ECMWF Copernicus Europe's eyes on Earth European Commission

Latest CAMS global system (IFS cycle 43r1, from 24 January)

- **New source of anthropogenic SOA based on scaled CO emissions**
- Faster sulphur cycle ($SO_2 \rightarrow SO_4$ conversion, deposition)
- Adjusted regional dust emission potential and size distribution

Secondary Organic Aersosols (SOA)

- Part of the OM species
- Replaced the Dentener et al. (2006) dataset with scaled anthropogenic CO emissions
- Better representation of the anthropogenic impact on SOA production
- Increases SOA production from ~20 Tg per year to ~140 Tg per year, closer to most recent estimates.



July: old (top) and new (bottom) SOA production flux in kg/(m².s)

Samuel Remy

Next CAMS global system (IFS cycle 43r3, expected mid-September)

- Updated aerosol optical properties (esp. for organic matter)
- Further adjustment of sulphur cycle oxidation and deposition
- Correction of sea salt sedimentation rate

Current developments (for 2018 and beyond)

- **Ammonium nitrate**
- **Coupling with gas-phase chemistry**
- **Updated online sea-salt and dust emission schemes**
- **Online-calculated dry deposition velocities**
- *Sub-grid-scale volcano heights for outgassing* SO_2 *emissions*

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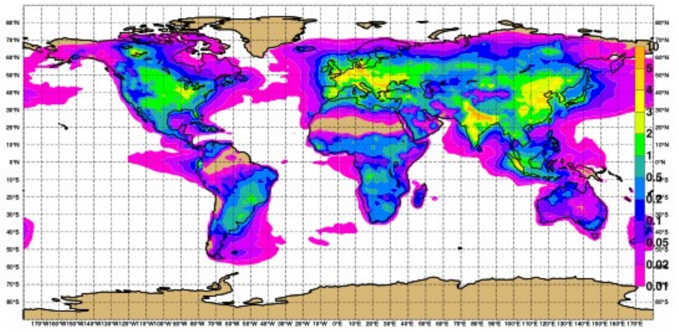
Introducing nitrate and ammonium aerosol (Hauglustaine et al., 2014)

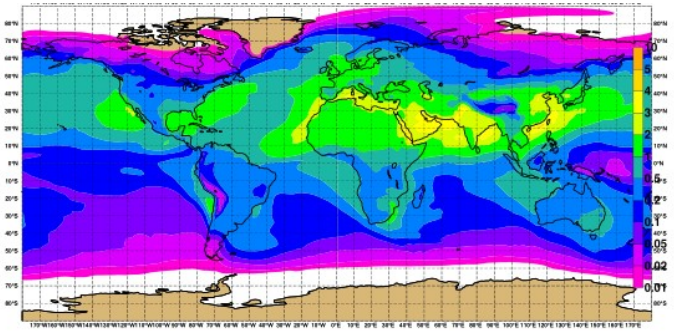
- Three new aerosol bins:
  - Fine mode nitrate, partitioned with gas phase: $HNO_3 + NH_3 \leftrightarrow NH_4NO_3.$
  - Coarse mode nitrate from heterogeneous reactions of HNO_3 over calcite (dust) and sea-salt particles: $HNO_3 + NaCl \rightarrow NaNO_3 + HCl,$
  - Ammonium $2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + H_2CO_3.$
- Simulated 2–7 µg m^{-3} in polluted areas, generally overestimated compared to EMEP and AIRBASE
- Improved PM10 and AOD scores over Europe

Samuel Remy

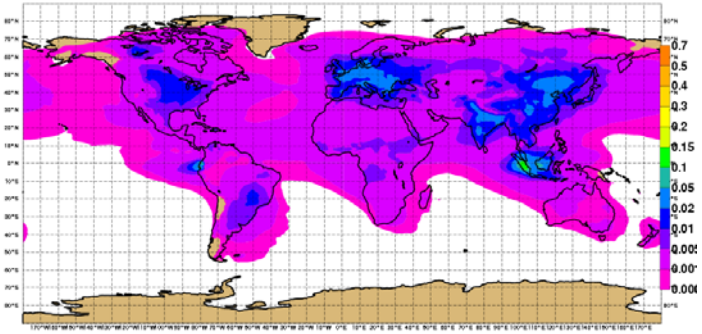
Fine NO_3^- concentration



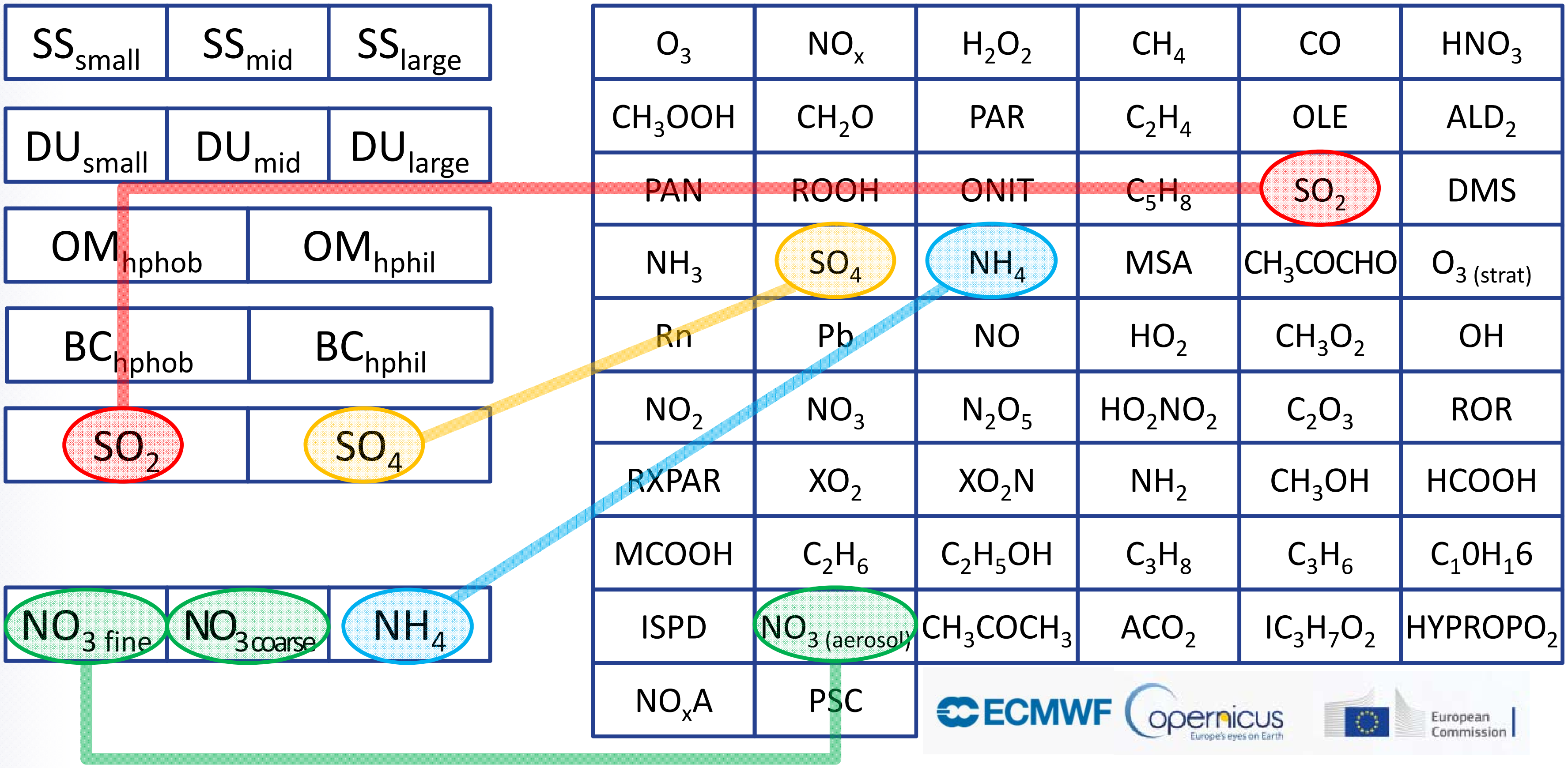
Coarse NO_3^- concentration



Nitrate AOD



Coupling aerosol and gas-phase sulphur cycles



Aerosol (LOA/LMD-Z)

SS_{small}	SS_{mid}	SS_{large}
DU_{small}	DU_{mid}	DU_{large}
OM_{hphob}	OM_{hphil}	
BC_{hphob}	BC_{hphil}	
SO_2	SO_4	
$NO_{3\ fine}$	$NO_{3\ coarse}$	NH_4

Chemistry (CB05)

O_3	NO_x	H_2O_2	CH_4	CO	HNO_3
CH_3OOH	CH_2O	PAR	C_2H_4	OLE	ALD_2
PAN	ROOH	ONIT	C_5H_8	SO_2	DMS
NH_3	SO_4	NH_4	MSA	CH_3COCHO	$O_{3\ (strat)}$
Rn	Pb	NO	HO_2	CH_3O_2	OH
NO_2	NO_3	N_2O_5	HO_2NO_2	C_2O_3	ROR
RXPAR	XO_2	XO_2N	NH_2	CH_3OH	HCOOH
MCOOH	C_2H_6	C_2H_5OH	C_3H_8	C_3H_6	C_10H_16
ISPD	$NO_{3\ (aerosol)}$	CH_3COCH_3	ACO_2	$IC_3H_7O_2$	$HYPROPO_2$
NO_xA	PSC				

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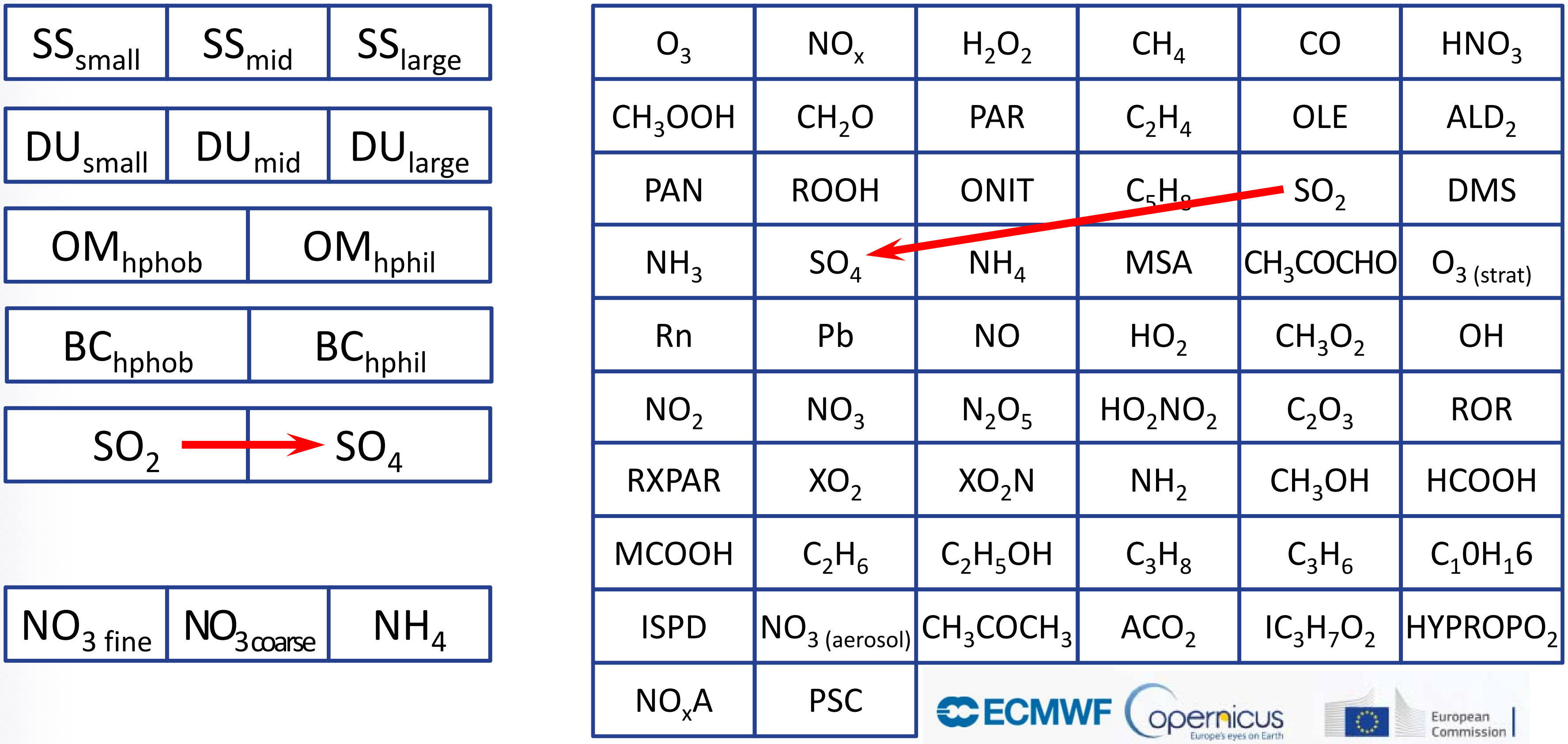
Coupling aerosol and gas-phase sulphur cycles



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$SO_2 \rightarrow SO_4$

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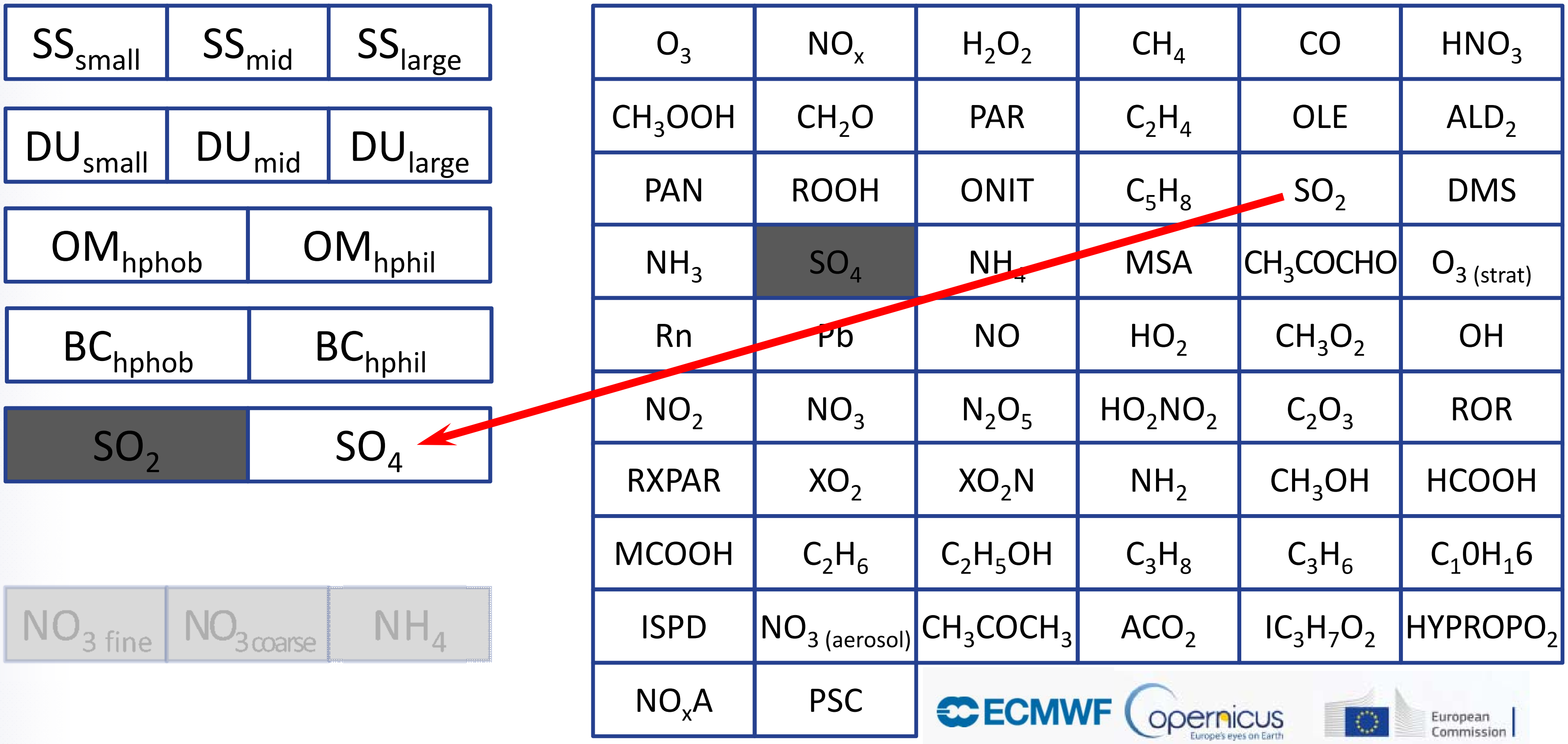
CH_3OOH	CH_2O	PAR	C_2H_4	OLE	ALD_2
PAN	ROOH	ONIT	C_5H_8	SO_2	DMS
NH_3	SO_4	NH_4	MSA	CH_3COCHO	$O_{3\ (strat)}$
Rn	Pb	NO	HO_2	CH_3O_2	OH
NO_2	NO_3	N_2O_5	HO_2NO_2	C_2O_3	ROR
RXPAR	XO_2	XO_2N	NH_2	CH_3OH	HCOOH
MCOOH	C_2H_6	C_2H_5OH	C_3H_8	C_3H_6	C_10H_16
ISPD	$NO_{3\ (aerosol)}$	CH_3COCH_3	ACO_2	$IC_3H_7O_2$	$HYPROPO_2$
NO_xA	PSC				

$SO_2 \rightarrow SO_4$

ECMWF opernicus Europe's eyes on Earth European Commission

Coupling aerosol and gas-phase sulphur cycles



Aerosol (LOA/LMD-Z)

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DU_{small}	DU_{mid}	DU_{large}
OM_{hphob}	OM_{hphil}	
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SO_2	SO_4	
$NO_{3\ fine}$	$NO_{3\ coarse}$	NH_4

Chemistry (CB05)

O_3	NO_x	H_2O_2	CH_4	CO	HNO_3
CH_3OOH	CH_2O	PAR	C_2H_4	OLE	ALD_2
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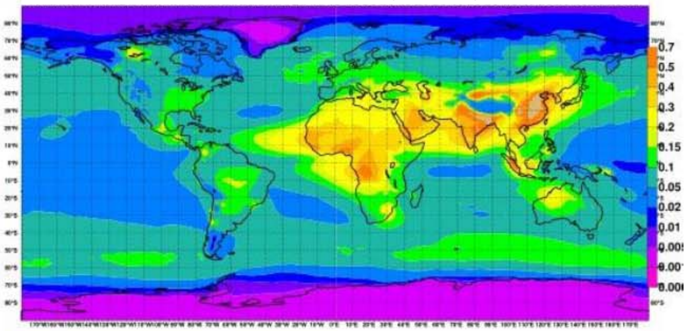
NH_3	SO_4	NH_4	MSA	CH_3COCHO	$O_{3\ (strat)}$
Rn	Pb	NO	HO_2	CH_3O_2	OH
NO_2	NO_3	N_2O_5	HO_2NO_2	C_2O_3	ROR
RXPAR	XO_2	XO_2N	NH_2	CH_3OH	HCOOH
MCOOH	C_2H_6	C_2H_5OH	C_3H_8	C_3H_6	C_10H_16
ISPD	$NO_{3\ (aerosol)}$	CH_3COCH_3	ACO_2	$IC_3H_7O_2$	$HYPROPO_2$
NO_xA	PSC				

A new sea-salt scheme: Grythe et al. (2014)

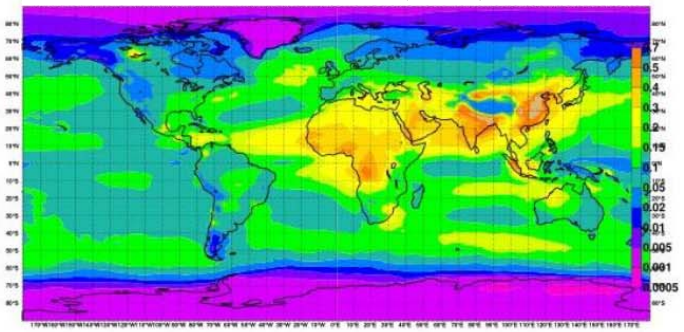
- Replaces older Monahan et al. (1986) scheme
- Wind scaling varies on particle size
- Emissions increase with SST

Emis. / Tg	M86	G14
Bin 1	0.022	0.033
Bin 2	1.928	1.462
Bin 3	2.344	36.37
Total	2.73	13.61

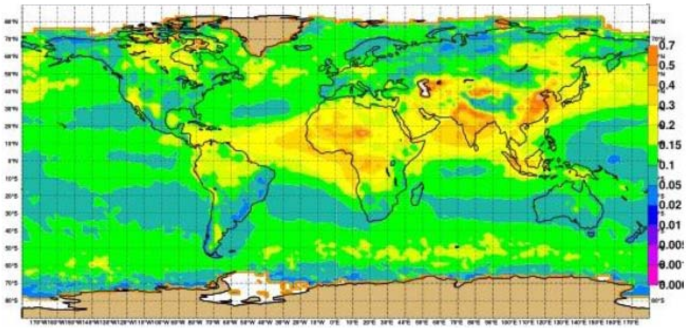
Old scheme (M86)



New scheme (G14)



MODIS C6

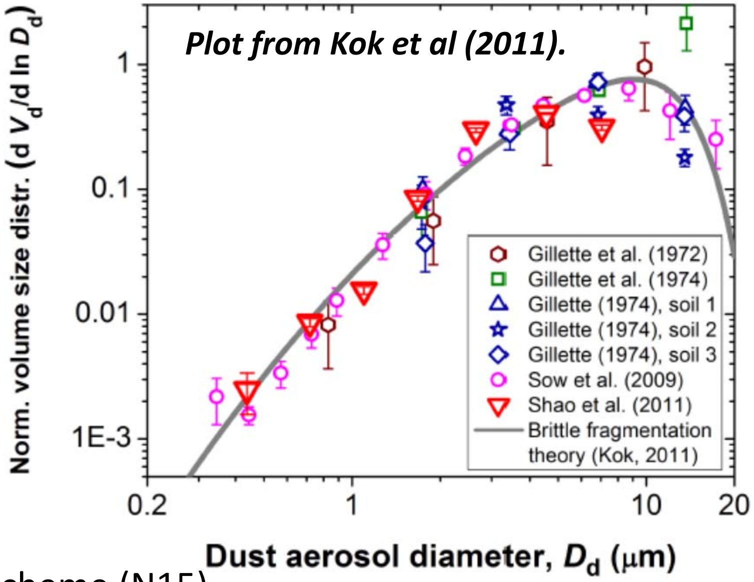


PM*x* over Europe, and evaluation against AERONET also improved.

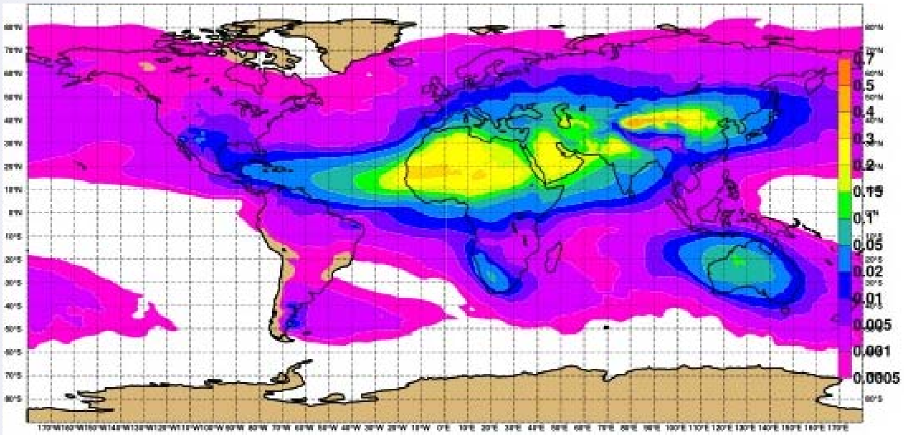
A new dust scheme: Nabat et al. (2015)

- Replaces older Ginoux et al. (2001).
- Marticorena and Bergametti (1995) saltation
- Kok et al. (2011) size distribution at emission
- Sand and clay fraction from SURFEX (Météo-Fr)

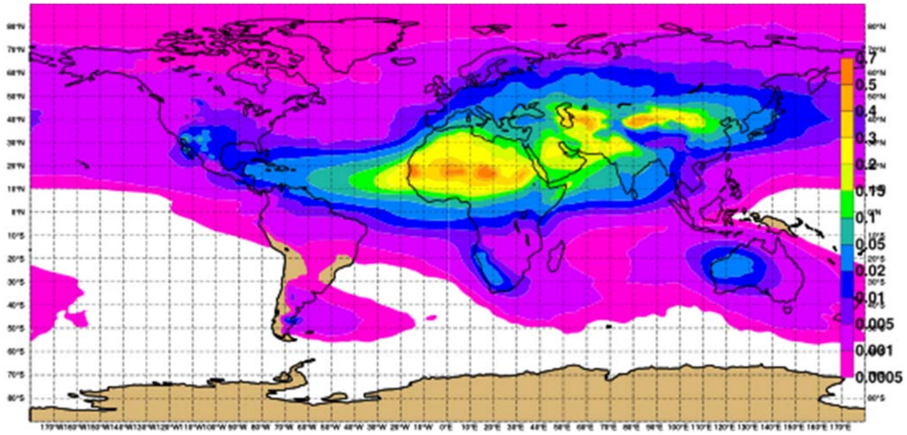
- 4-fold increase in super-coarse particles
- Greater total emissions



Old scheme (G01)



New scheme (N15)



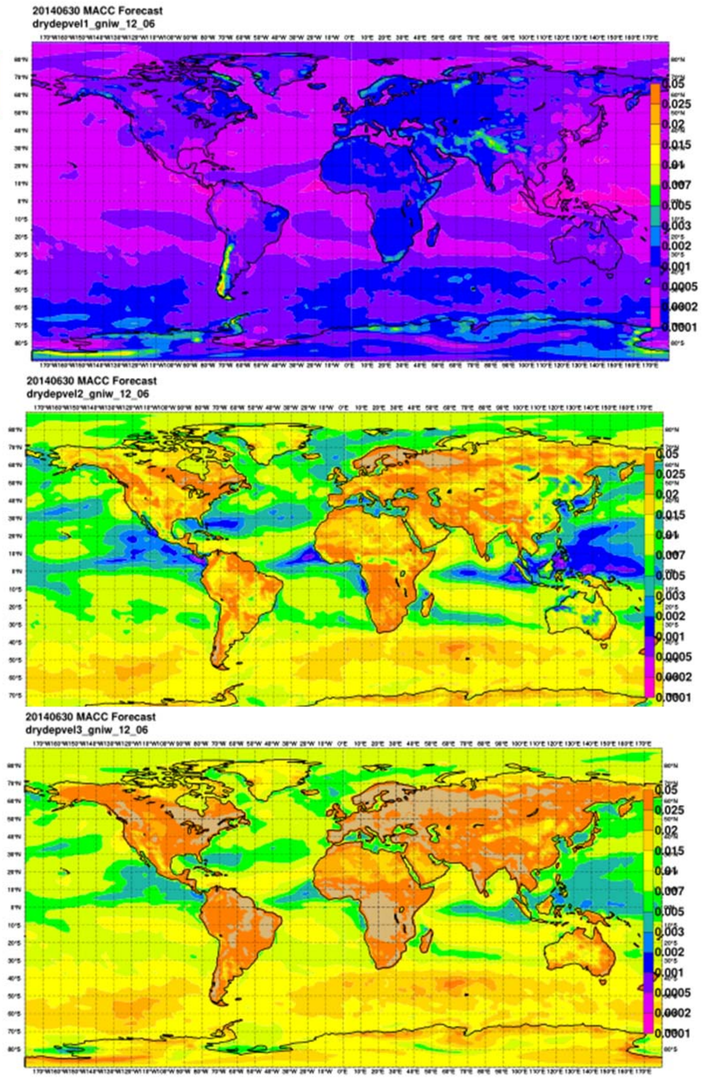
Online dry deposition velocities

- Replaces fixed deposition velocities for each species and surface type (land/sea/ice)

- Adaptation of Zhang et al. (2001) computing online dry deposition velocities from:
  - Particle size
  - Friction velocity
  - Roughness length

- Important diurnal and seasonal cycle of dry deposition velocities

- Positive impact on European PM10 and AERONET scores



June 2014: dry deposition velocities for sea-salt bin 1 (top), 2 (middle) and 3 (bottom), in m/s.

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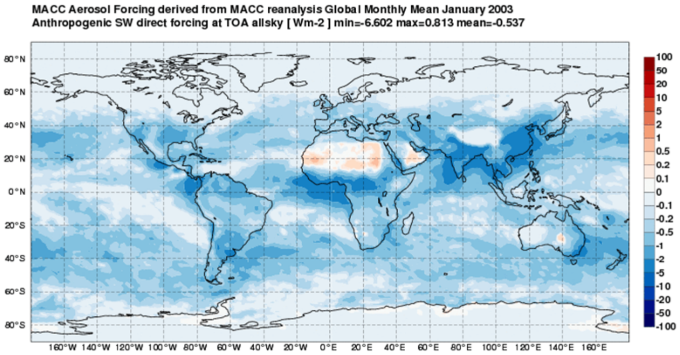
Other technical and changes

- Aerosols included in global mass fixer (43r1)
- Diagnostic outputs at step 0: AOD (43r1), PM*x* (43r3), many more (45r1)
- Ground-based lidar backscatter available (43r3)

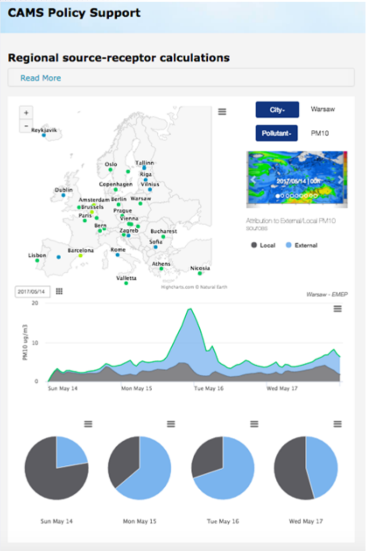
Atmosphere Monitoring

Downstream CAMS products


MACC Aerosol Forcing derived from MACC reanalysis Global Monthly Mean January 2003
Anthropogenic SW direct forcing at TOA allsky [Wm-2] min=-6.602 max=0.813 mean=-0.537

Climate forcing

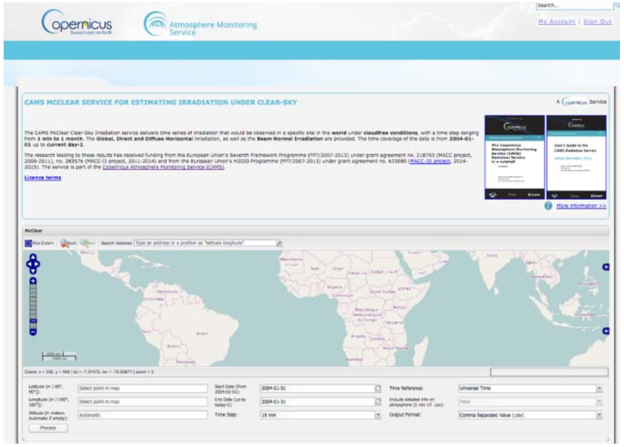
Policy


CAMS Policy Support

Regional source-receptor calculations

Read More

Solar radiation

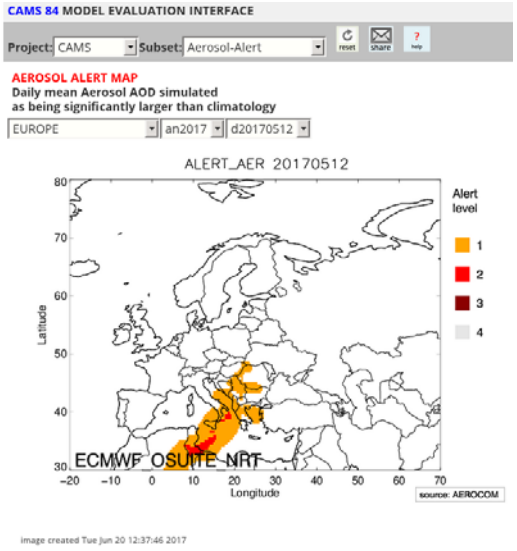

CAMS MCCLEAR SERVICE FOR ESTIMATING IRRADIATION UNDER CLEAR-SKY

The CAMS McClear Clear-Sky Irradiation service delivers time series of irradiation that would be observed in a specific site in the **world** under **cloudfree conditions**, with a time step ranging from **1 min to 1 month**. The **Global, Direct and Diffuse Horizontal** irradiation, as well as the **Beam Normal Irradiation** are provided. The time coverage of the data is from **2004-01-01** up to **current day-2**.

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement no. 218793 (MACC project, 2009-2011), no. 283576 (MACC-II project, 2011-2014) and from the European Union's H2020 Programme (FP7/2007-2013) under grant agreement no. 633080 (MACC-III project, 2014-2015). The service is part of the Copernicus Atmosphere Monitoring Service (CAMS).

Licence terms

Aerosol alerts


CAMS 84 MODEL EVALUATION INTERFACE

Project: CAMS **Subset:** Aerosol-Alert

AEROSOL ALERT MAP
Daily mean Aerosol AOD simulated
as being significantly larger than climatology

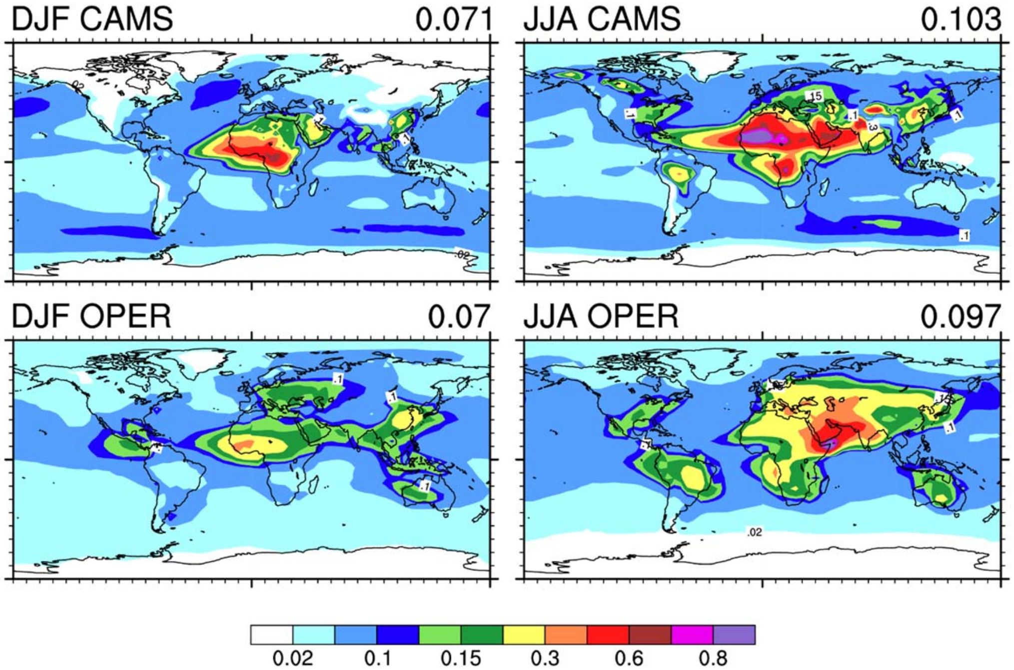
EUROPE | an2017 | d20170512

image created Tue Jun 20 12:37:46 2017

ECMWF Copernicus Europe's eyes on Earth European Commission

Updated IFS aerosol climatology using CAMS interim reanalysis

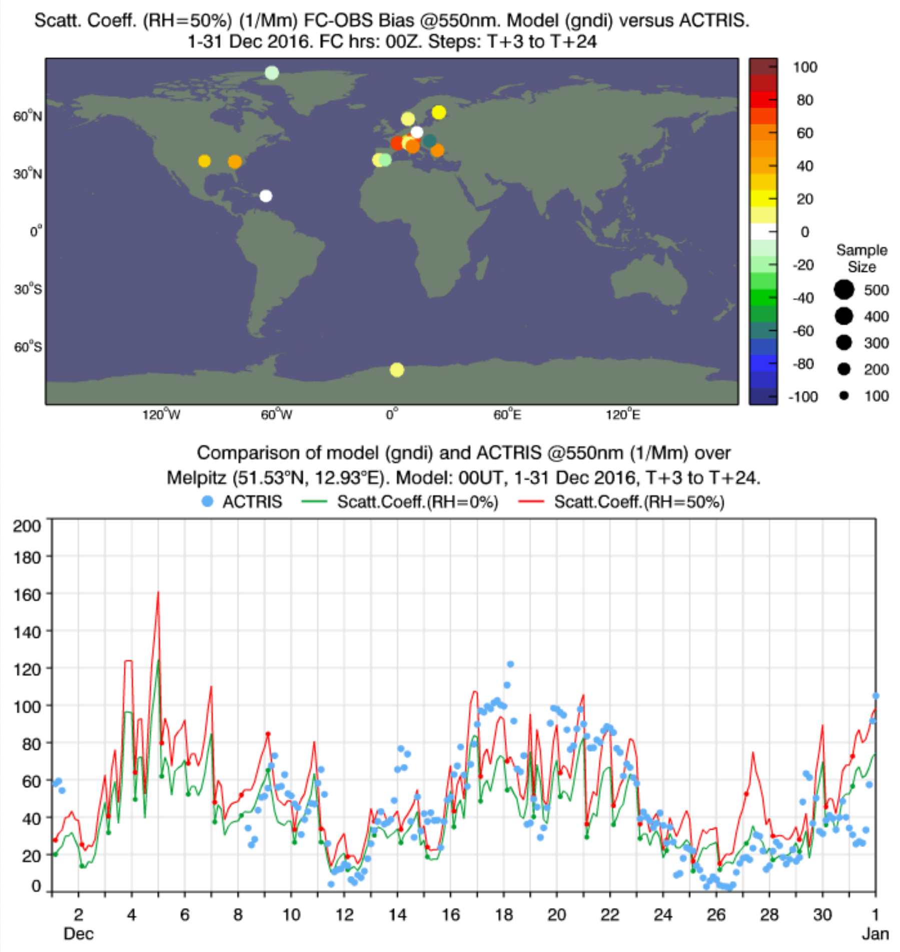
- Aerosol burdens from CAMS interim reanalysis 2003-2011. Old operational climatology from Tegen et al. 1997 climatology
- Impacts mostly on mean T biases and gradients (largely from SW absorption). Small impact on large scale anomaly correlation and local circulations.



AOD @550nm

Atmosphere Monitoring

Scattering coefficient verification near to the surface

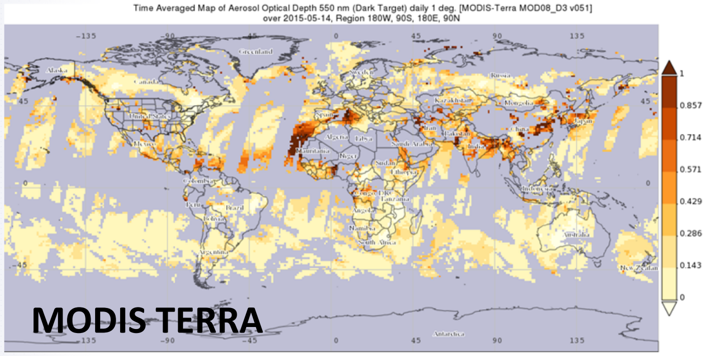


- Comparisons have been performed between scattering coefficient at 550 nm from the model (C-IFS) and measurements at the surface (nephelometer).
- Some problems linked with the topography have still to be solved.

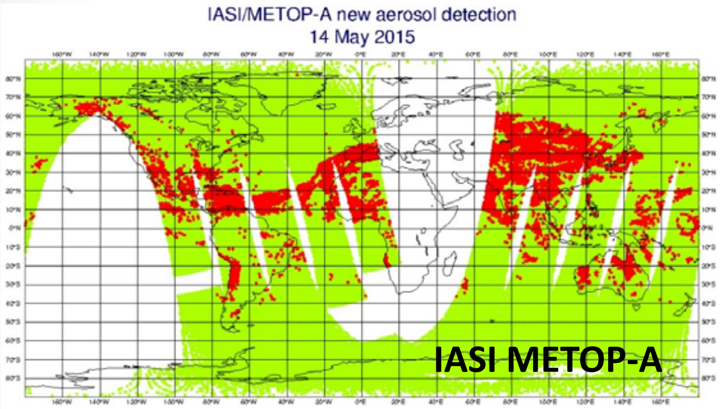
http://atmosphere.Copernicus.eu/charts/cams_actris_deliverable/

Julie Letertre-Danczak

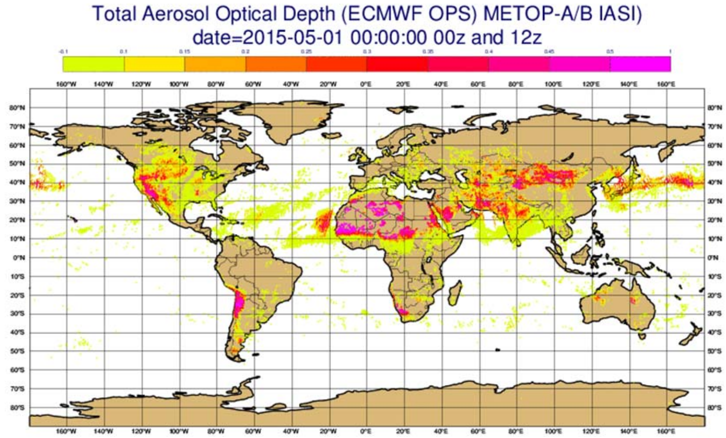
Aerosol detection and AOD at 10 microns


Time Averaged Map of Aerosol Optical Depth 550 nm (Dark Target) daily 1 deg. [MODIS-Terra MOD08_D3 v051] over 2015-05-14, Region 180W, 90S, 180E, 90N

Red dots : aerosol detection


IASI/METOP-A new aerosol detection
14 May 2015

- Aerosol information for screening of the hyperspectral infrared instruments (AIRS, IASI A/B & CrIS) is needed for a successful clear-sky radiance assimilation
- Information can be extracted via the process of screening such as AOD at 10 microns (done) and altitude (under investigation).


Total Aerosol Optical Depth (ECMWF OPS) METOP-A/B IASI)
date=2015-05-01 00:00:00 00z and 12z

Julie Letertre-Danczak

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CAMS Aerosol Data Assimilation

ECMWF Copernicus Europe's eyes on Earth European Commission

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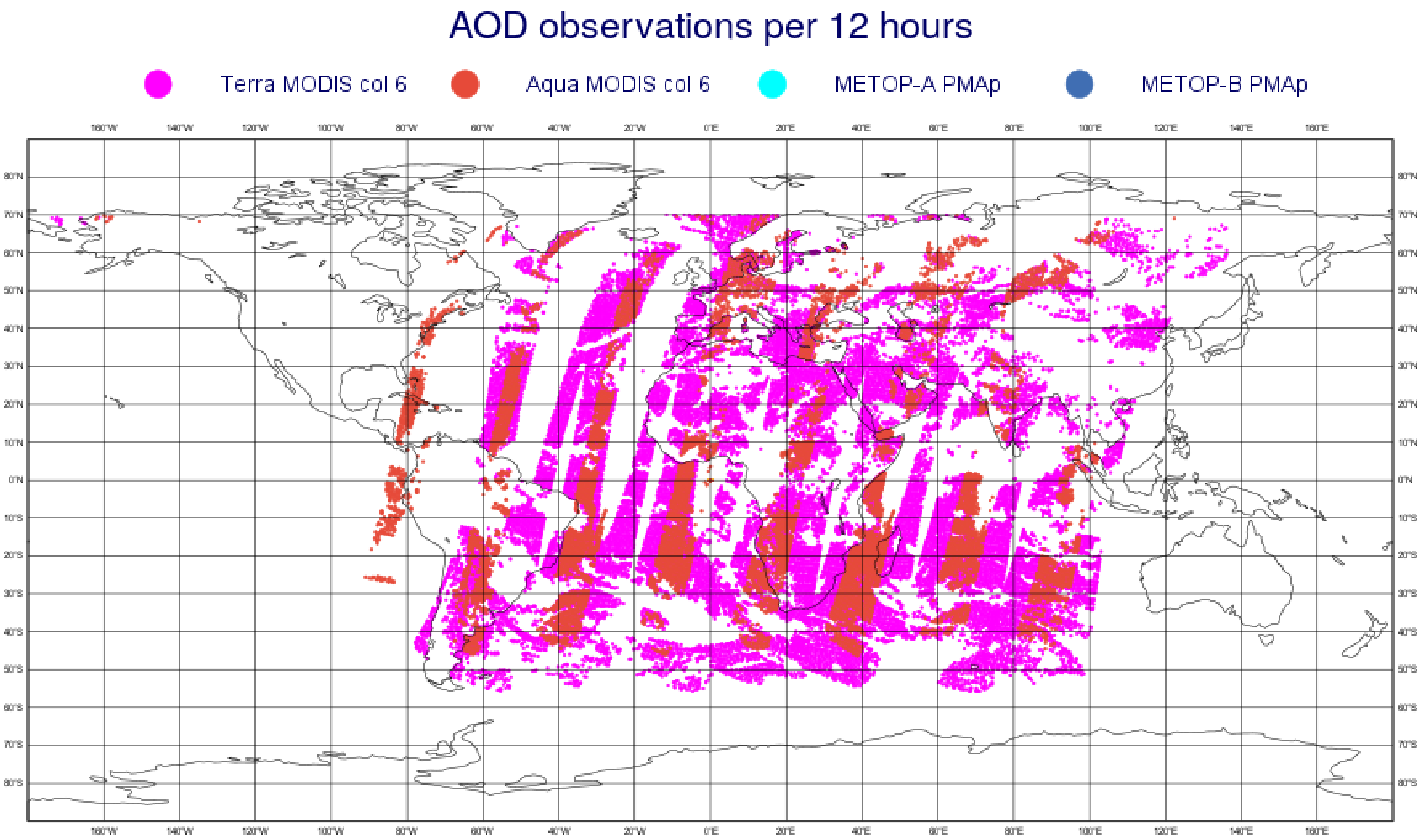
Aerosol Data Assimilation updates

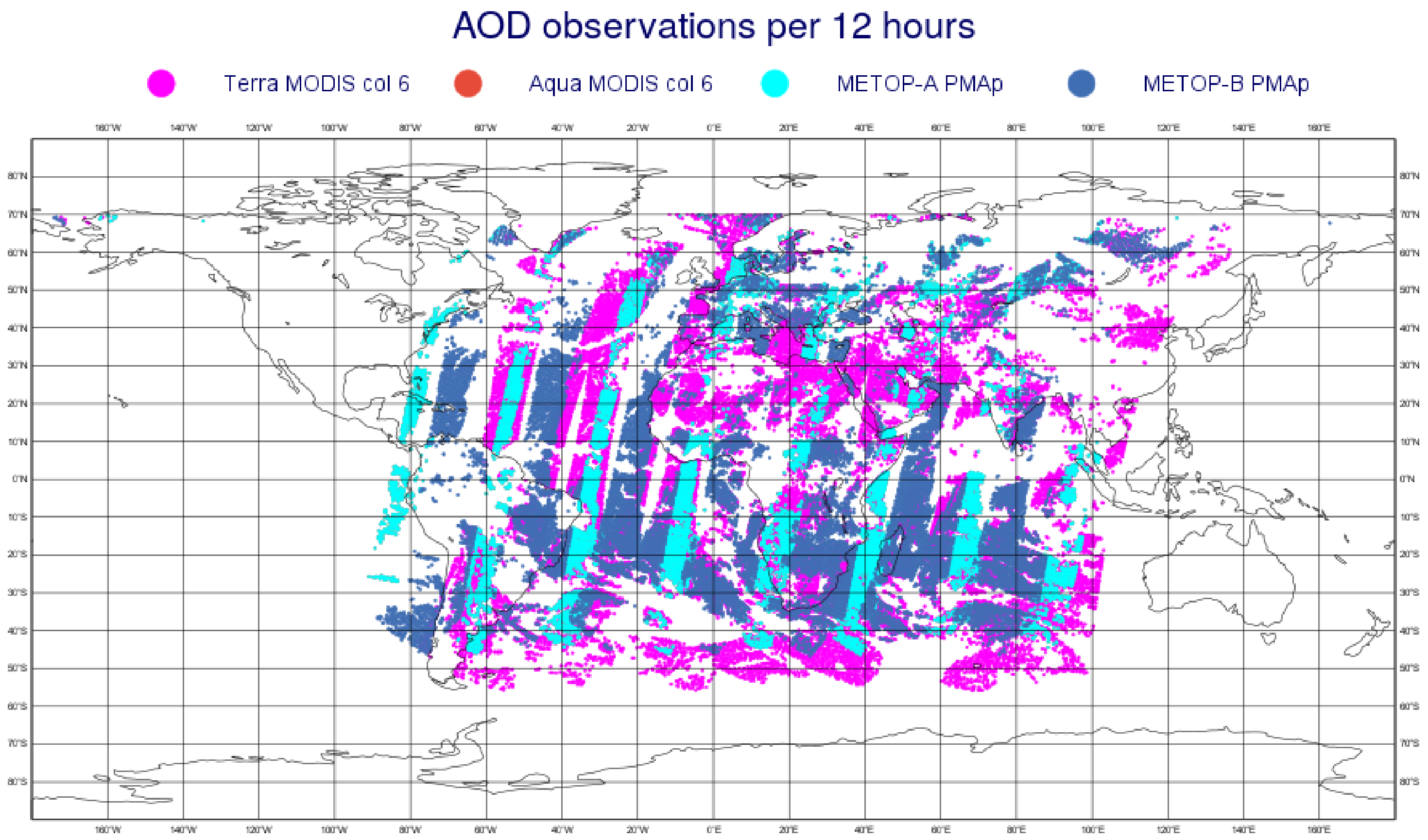

AOD observations per 12 hours

ECMWF

Copernicus
Europe's eyes on Earth

European
Commission

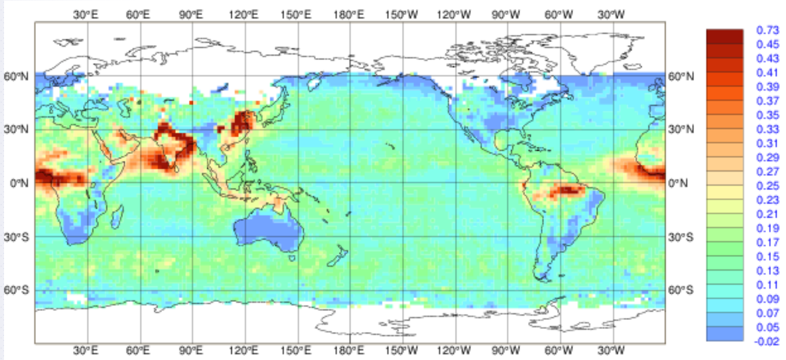
Aerosol Data Assimilation updates



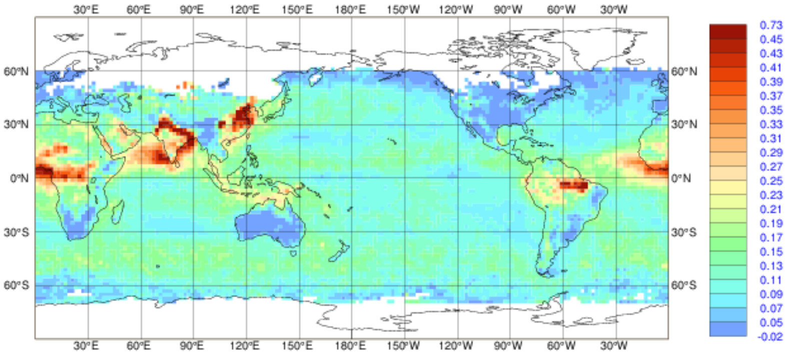
Atmosphere Monitoring

Mean AOD (14/11/2016-18/12/2016)

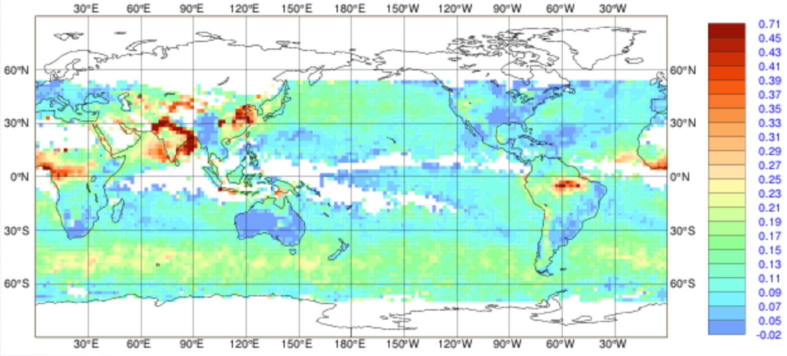
MODIS/Terra (collection 6)



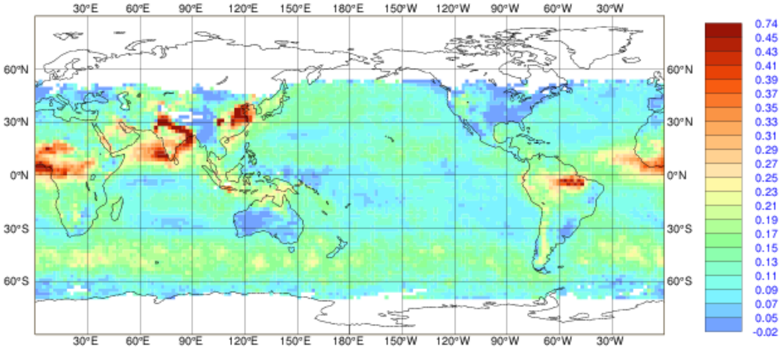
MODIS/Aqua (collection 6)



MODIS/Terra (collection 5)



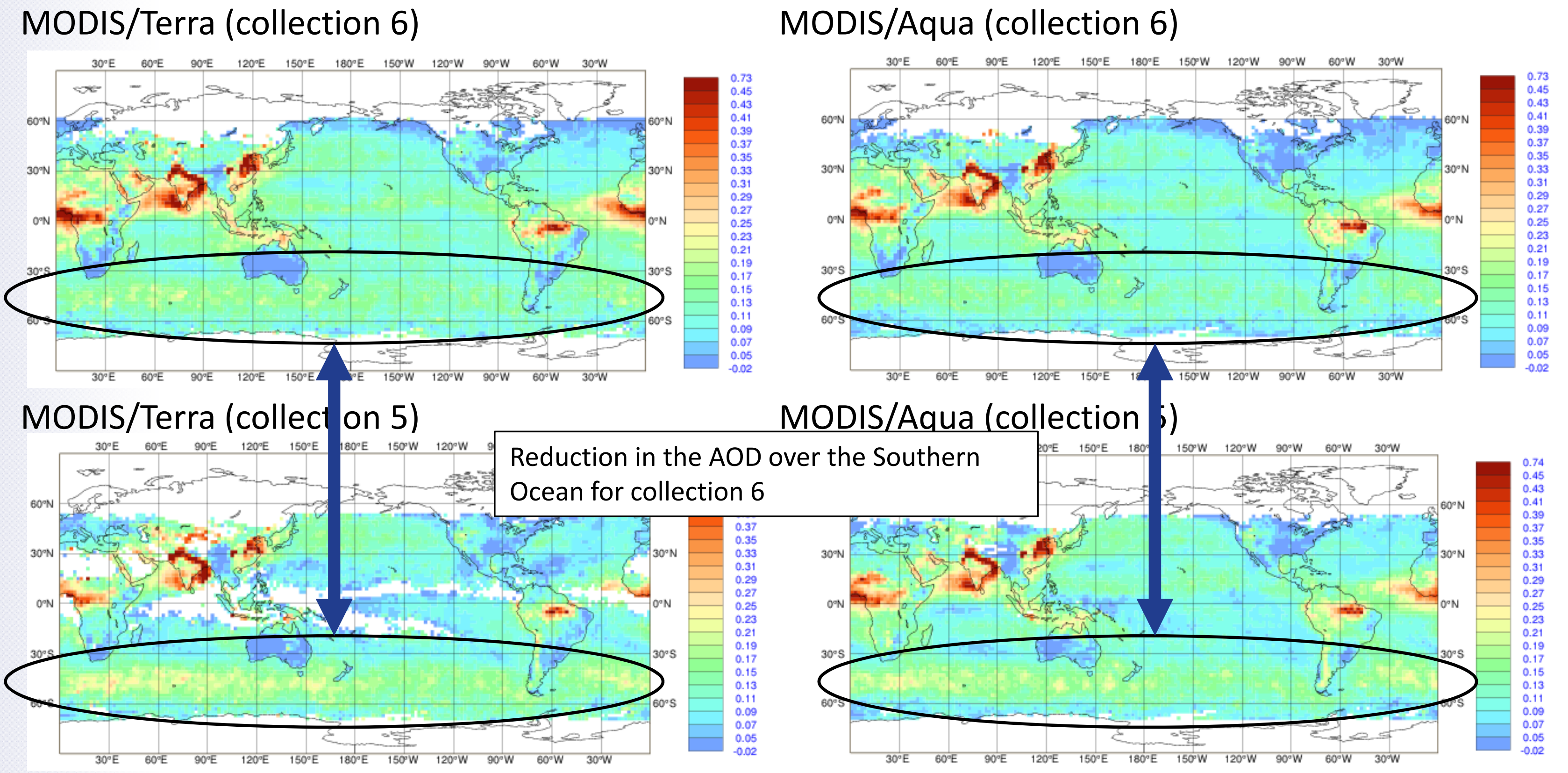
MODIS/Aqua (collection 5)



Results shown for Collection 5 and 6 NRT MODIS data (14/11/2016-18/12/2016)

Atmosphere Monitoring

Mean AOD (14/11/2016-18/12/2016)


MODIS/Terra (collection 6)

MODIS/Aqua (collection 6)

MODIS/Terra (collection 5)

MODIS/Aqua (collection 5)

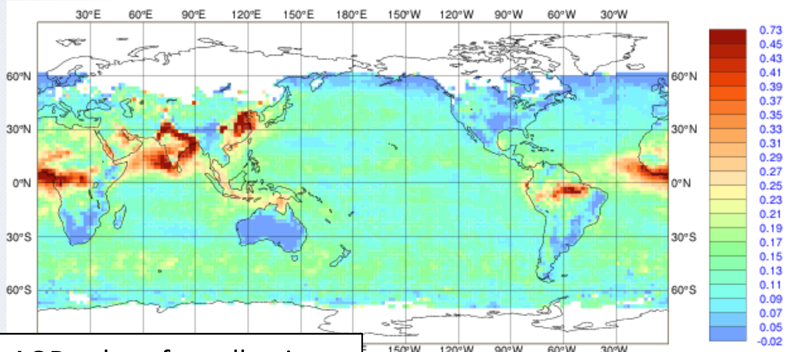
Reduction in the AOD over the Southern Ocean for collection 6

Results shown for Collection 5 and 6 NRT MODIS data (14/11/2016-18/12/2016)

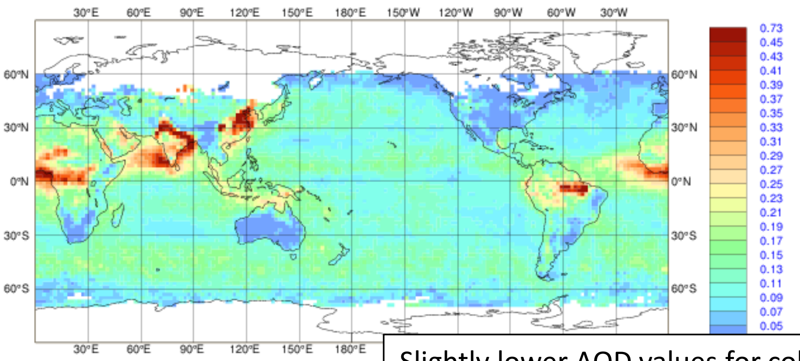
Atmosphere Monitoring

Mean AOD (14/11/2016-18/12/2016)

MODIS/Terra (collection 6)

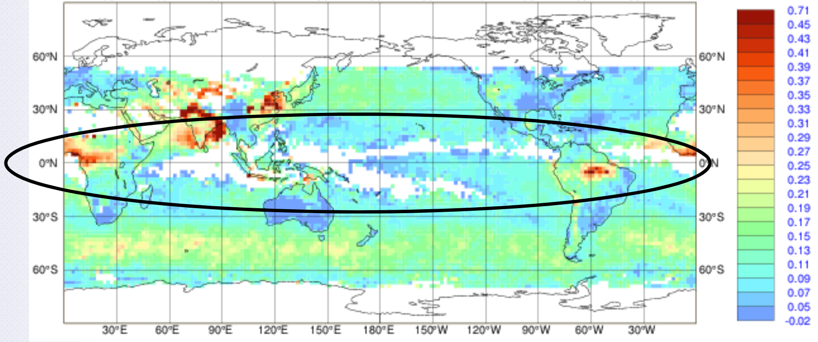


MODIS/Aqua (collection 6)

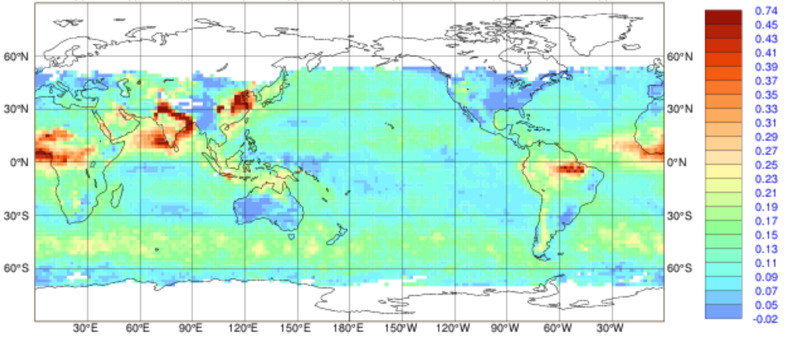


Generally higher AOD values for collection 6 from MODIS/Terra than collection 5

n 5)



MODIS/Aqua (collection 5)



Slightly lower AOD values for collection 6 from MODIS/Aqua than collection 5

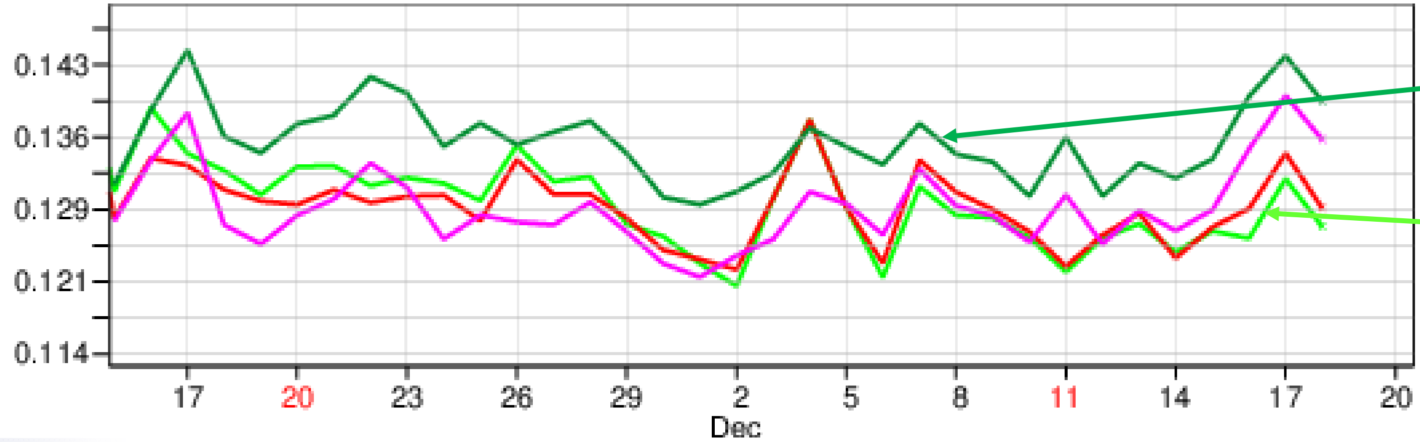
Results shown for Collection 5 and 6 NRT MODIS data (14/11/2016-18/12/2016)

Assimilation test of Collection 6 AOD

Atmosphere
Monitoring

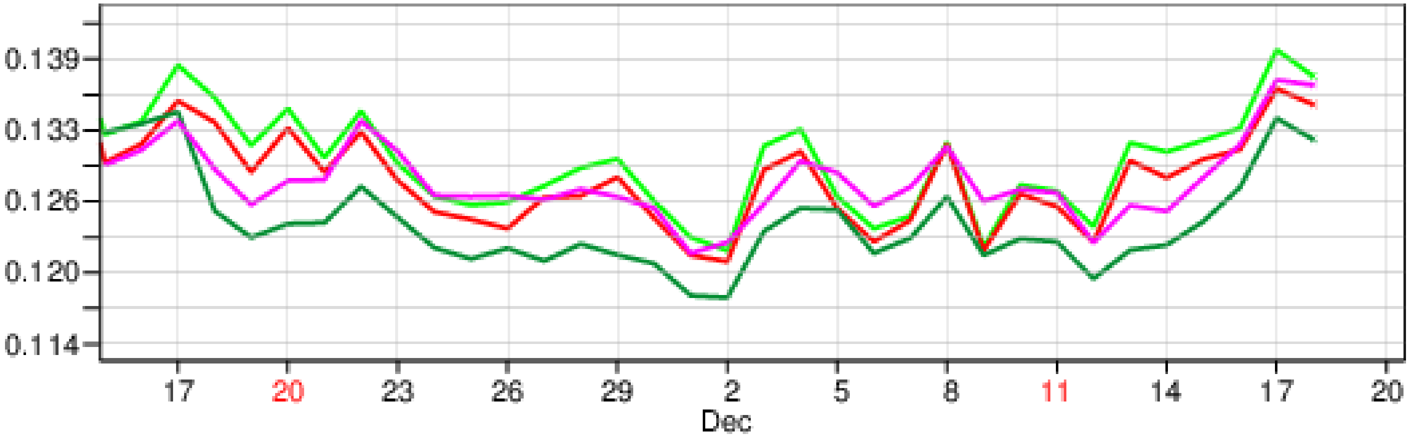
MODIS/Terra

AOD values



MODIS/Terra **collection 6** obs higher than MODIS/Terra **collection 5** obs

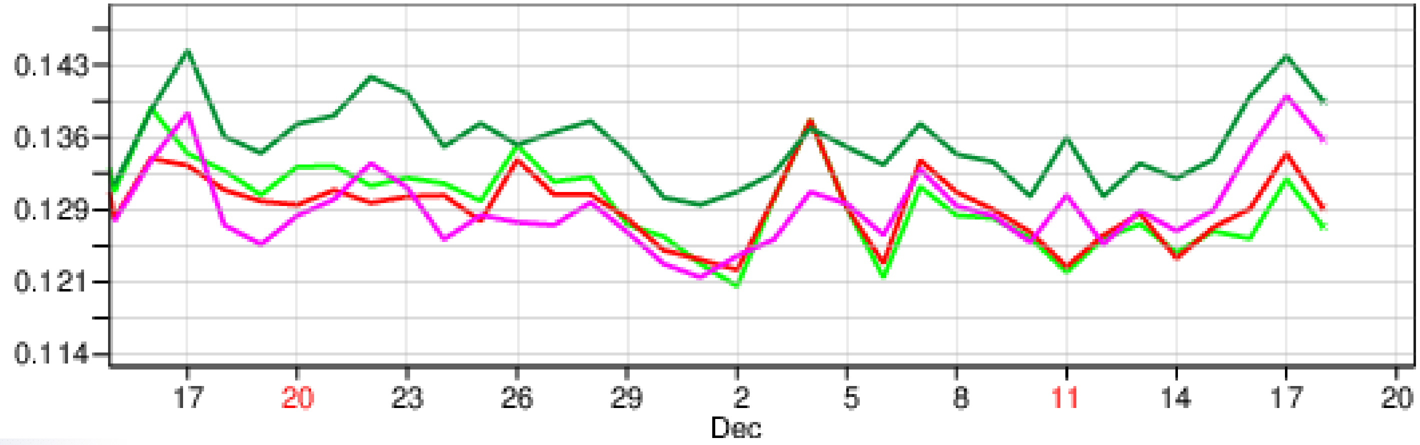
MODIS/Aqua



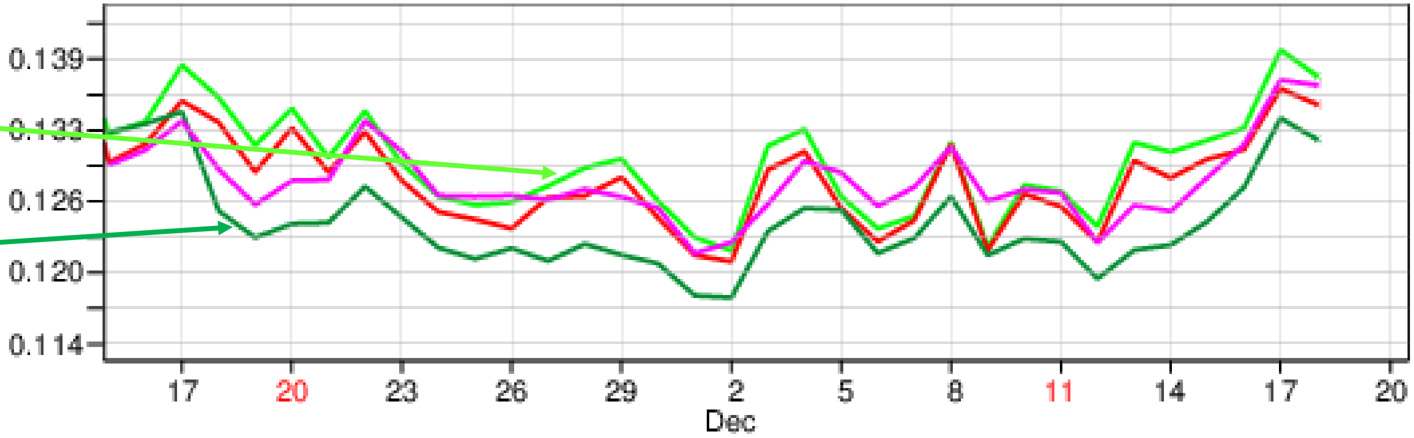
Assimilation test of Collection 6 AOD

MODIS/Terra

AOD values



MODIS/Aqua

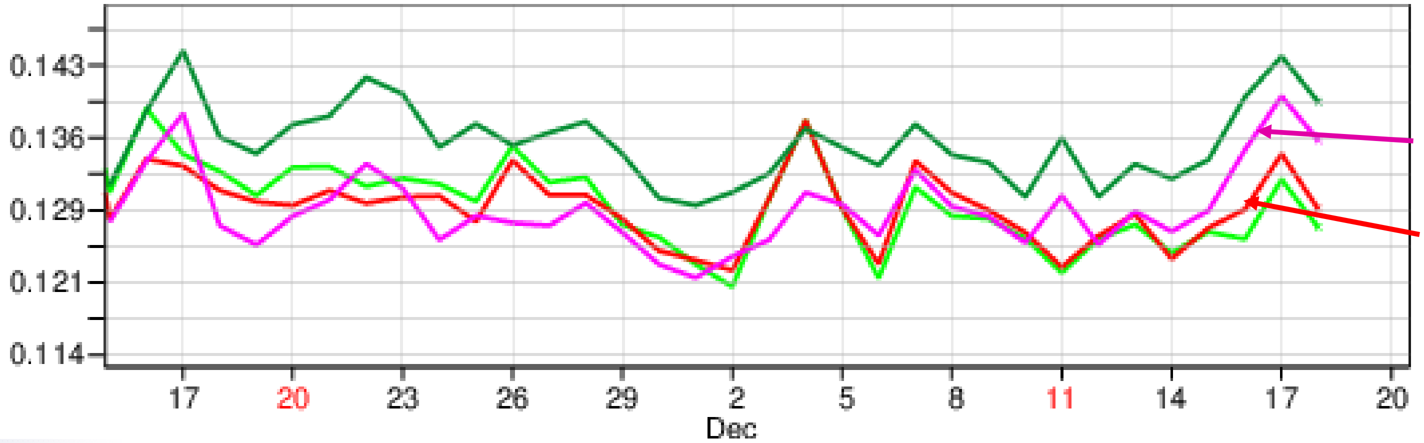


MODIS/Aqua
collection 5 obs
higher than
MODIS/Aqua
collection 6 obs

Assimilation test of Collection 6 AOD

MODIS/Terra

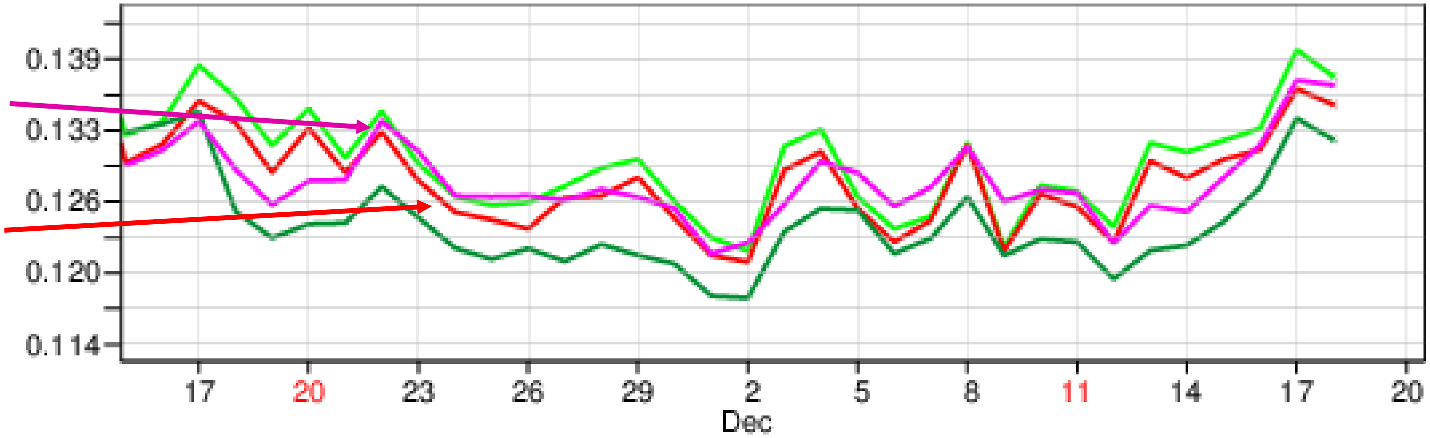
AOD values



Collection 6 analysis model state

Collection 5 analysis model state

MODIS/Aqua



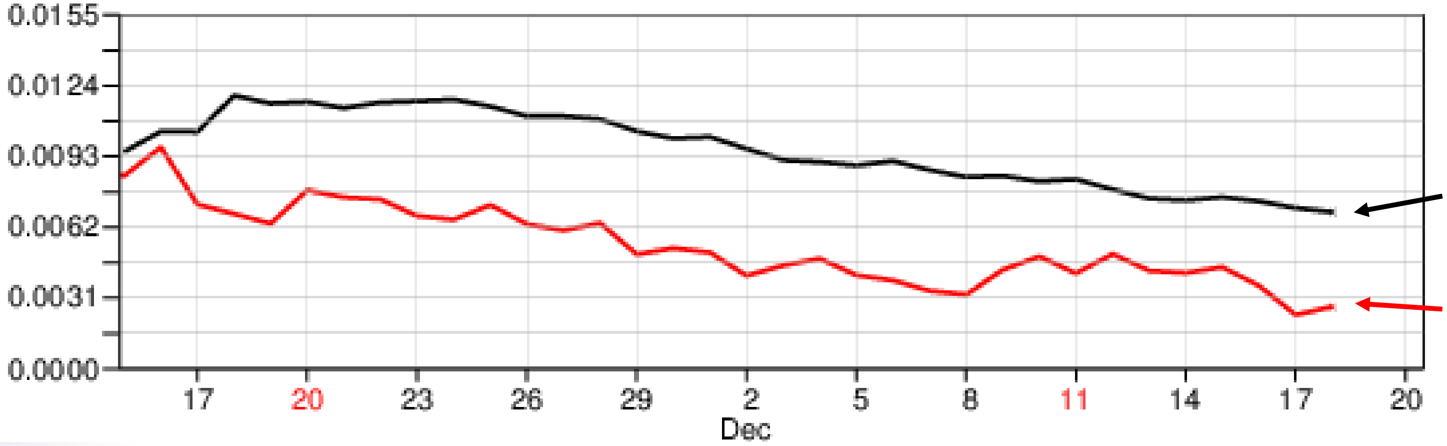
Collection 6 analysis model state

Collection 5 analysis model state

Atmosphere
Monitoring

Assimilation test of Collection 6 AOD

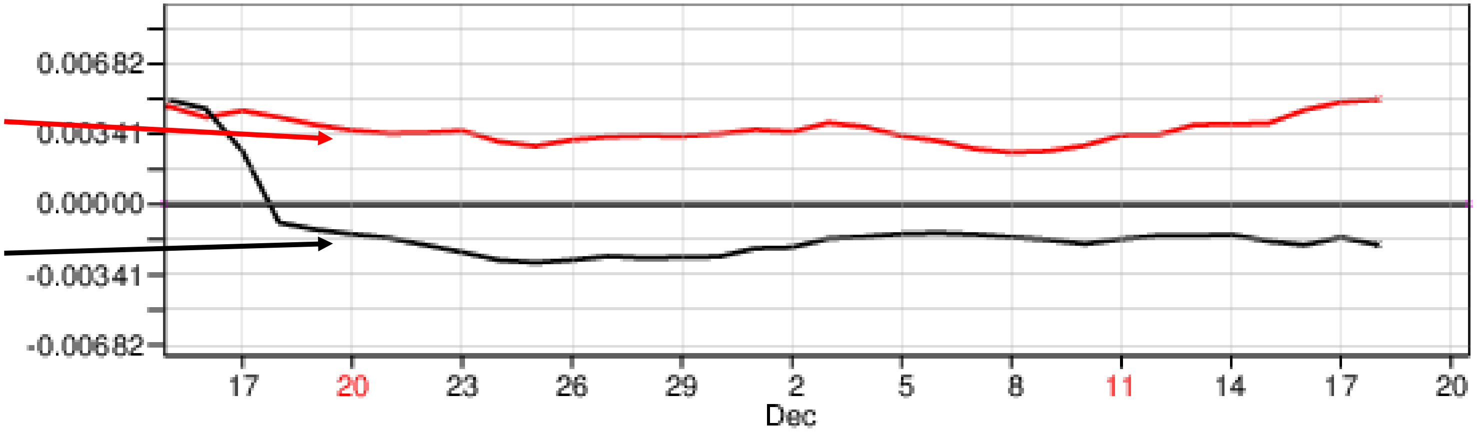
MODIS/Terra



MODIS/Terra **collection 6** bias higher than MODIS/Terra **collection 5** bias

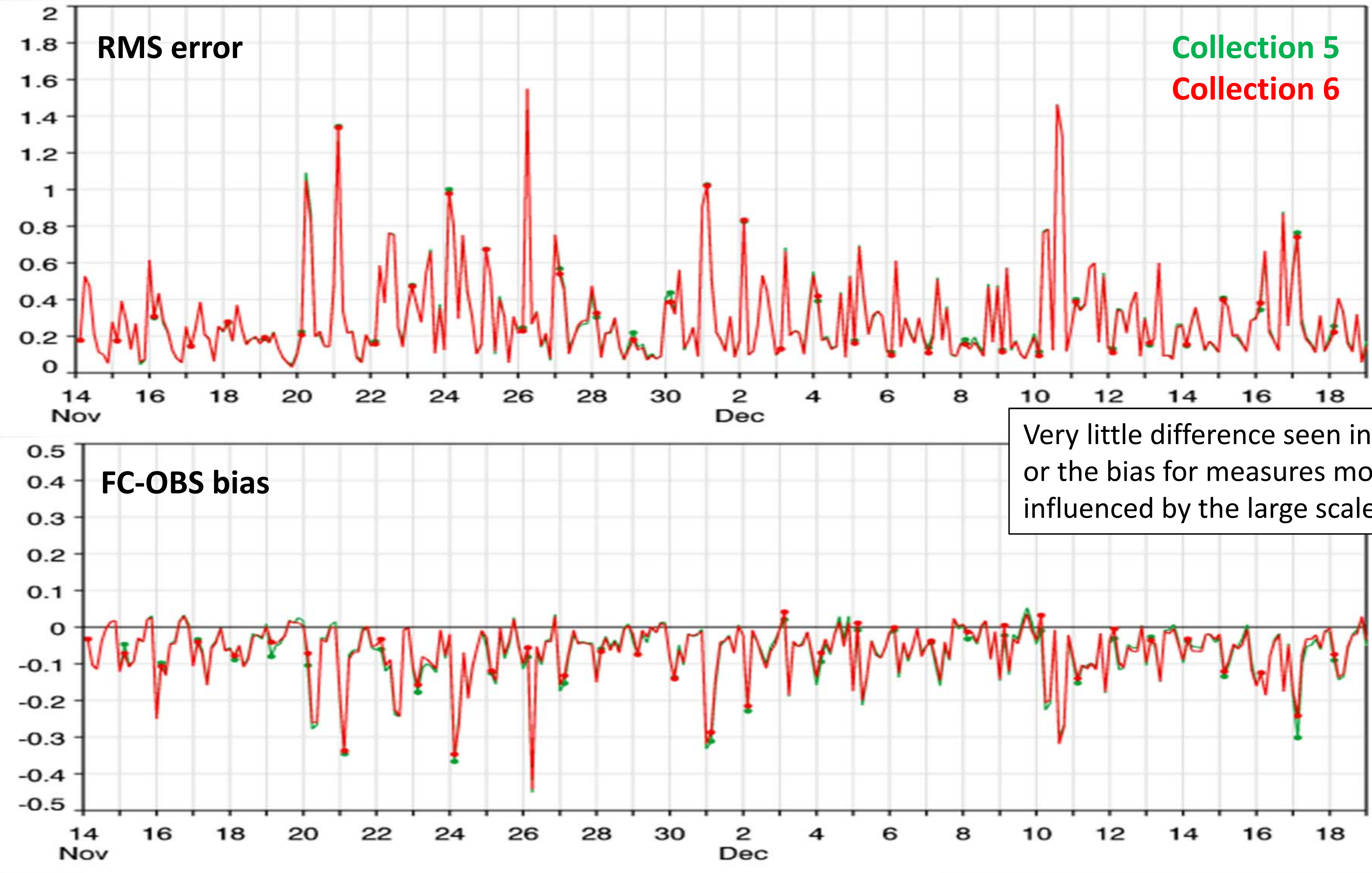
MODIS/Aqua

MODIS/Aqua **collection 5** bias higher than MODIS/Aqua **collection 6** bias



Atmosphere Monitoring

Aeronet verification



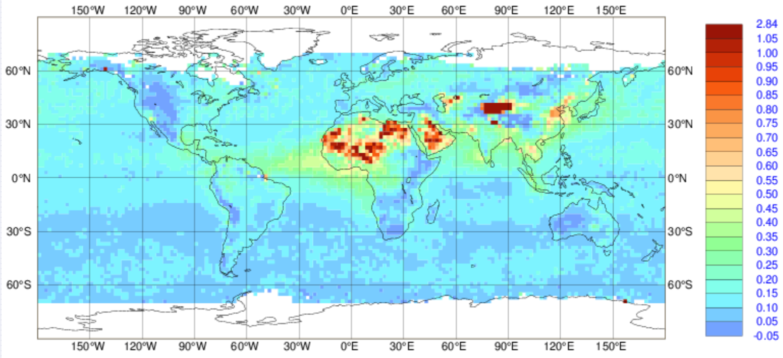
Very little difference seen in the error or the bias for measures more influenced by the large scale

European Commission

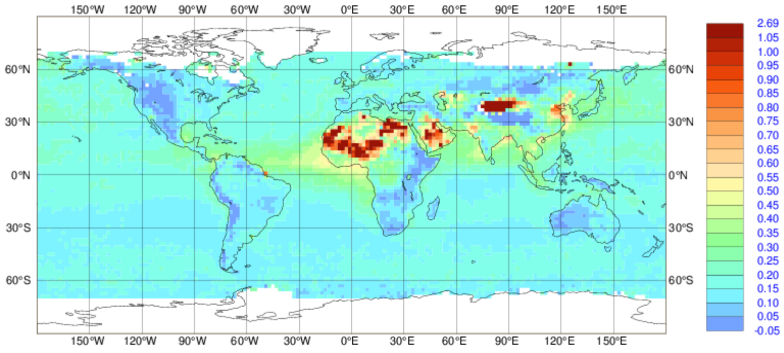
Atmosphere Monitoring

Mean AOD (1/02/2015-31/05/2015)

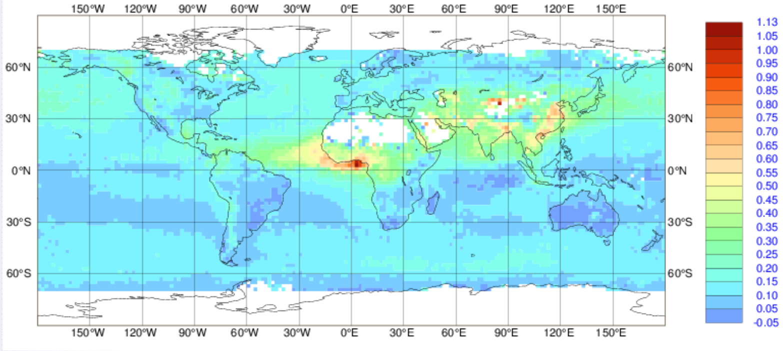
PMAp-A



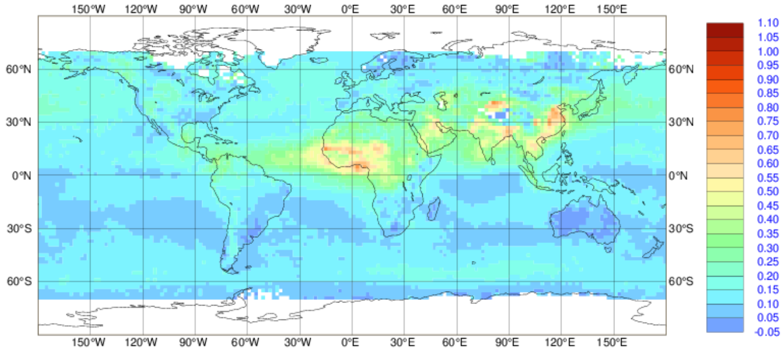
PMAp-B



MODIS/Terra



MODIS/Aqua

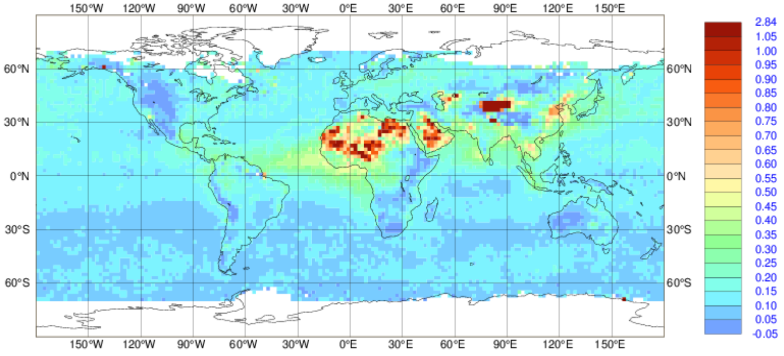


Results shown for PMAp V2.1 test data (1/2/2015-31/5/2015)

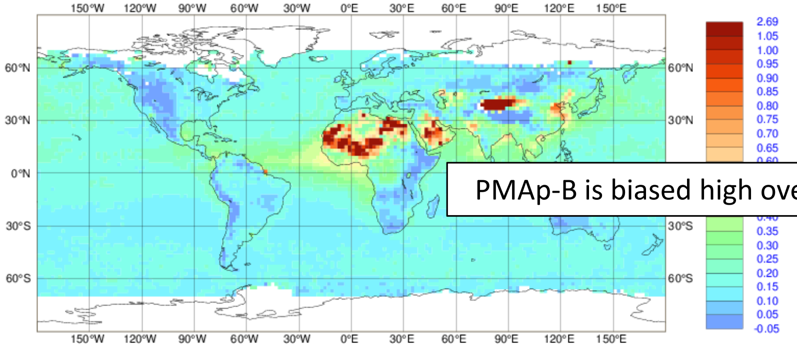
Atmosphere
Monitoring

Mean AOD (1/02/2015-31/05/2015)

PMAp-A

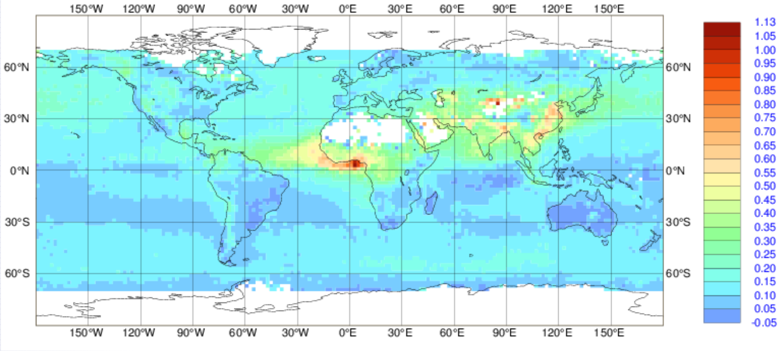


PMAp-B

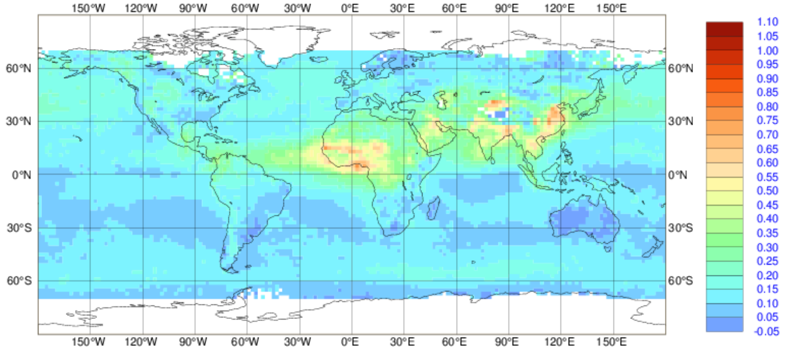


PMAp-B is biased high over the oceans

MODIS/Terra



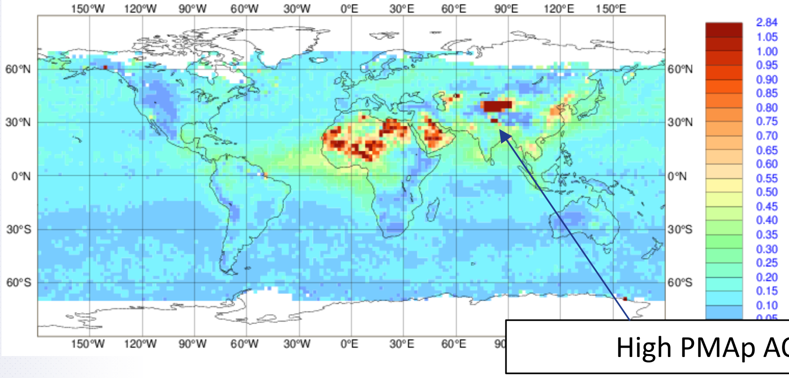
MODIS/Aqua



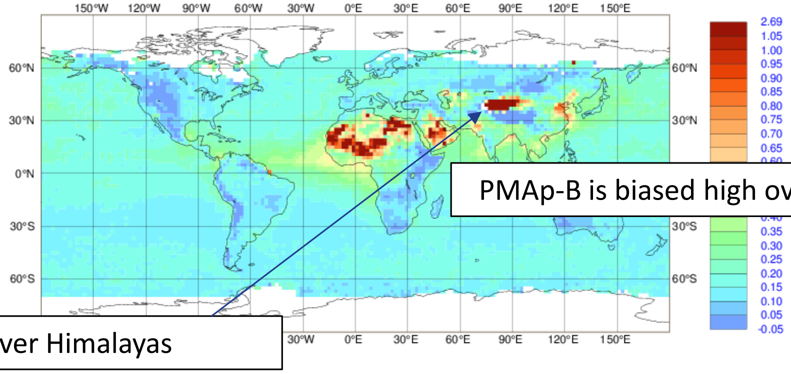
Results shown for PMAp V2.1 test data (1/2/2015-31/5/2015)

Mean AOD (1/02/2015-31/05/2015)

PMAp-A



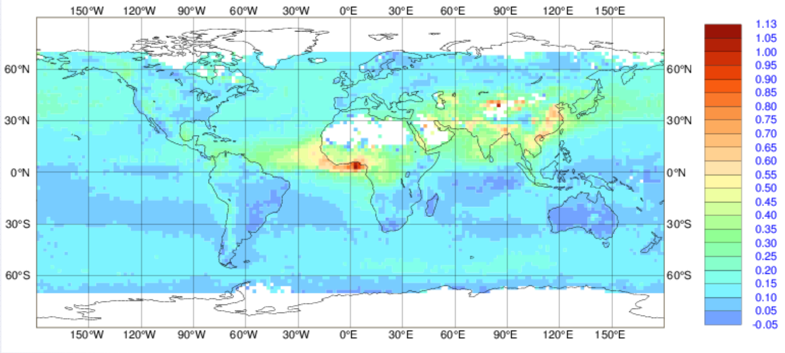
PMAp-B



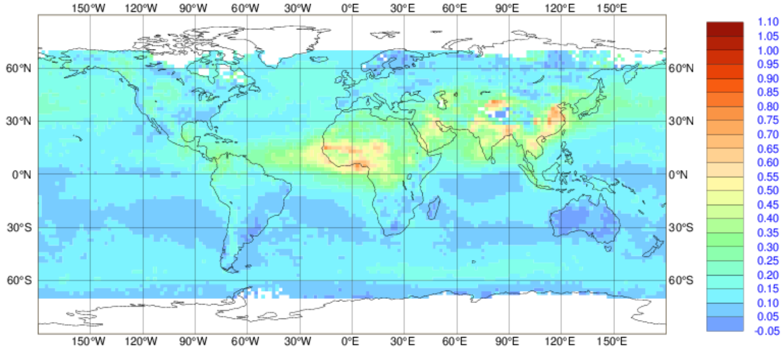
PMAp-B is biased high over the oceans

High PMAp AOD over Himalayas

MODIS/Terra



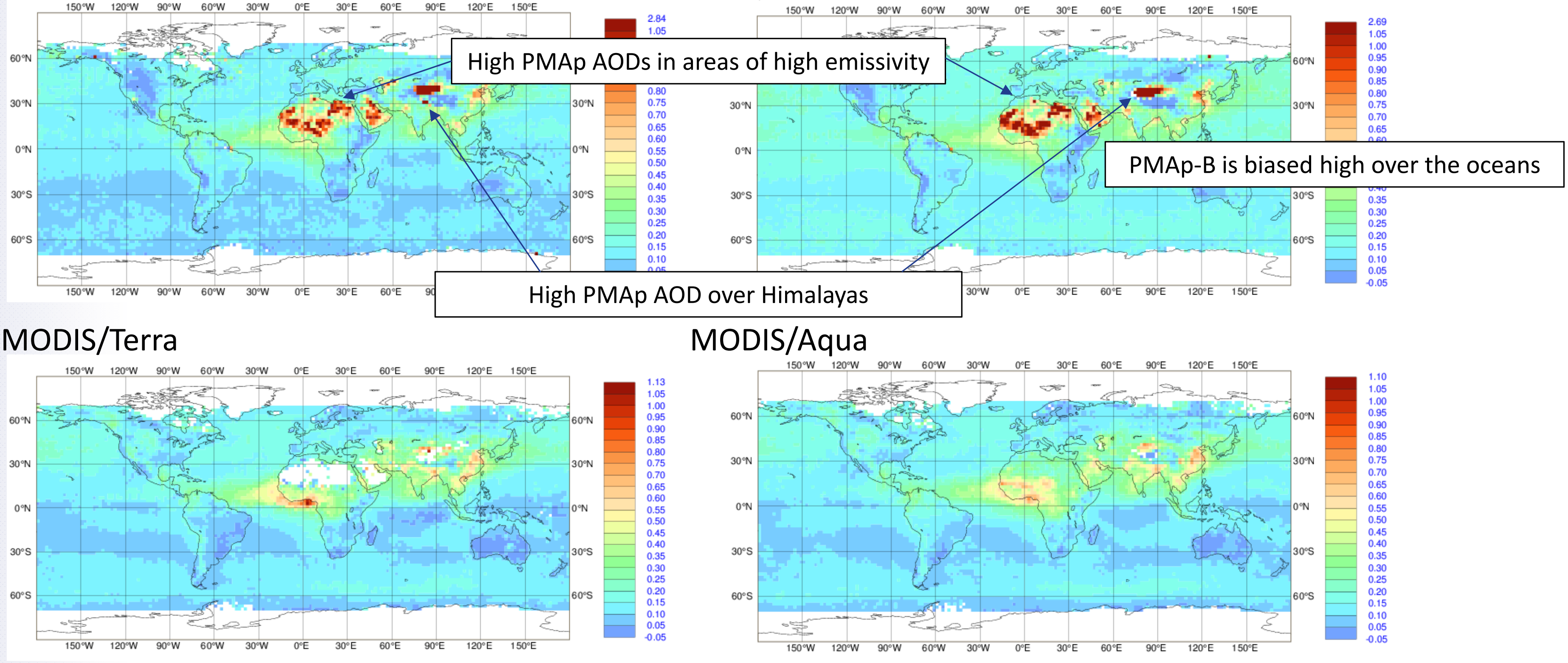
MODIS/Aqua



Results shown for PMAp V2.1 test data (1/2/2015-31/5/2015)

Atmosphere
Monitoring

Mean AOD (1/02/2015-31/05/2015)



PMAp-A

PMAp-B

High PMAp AODs in areas of high emissivity

PMAp-B is biased high over the oceans

High PMAp AOD over Himalayas

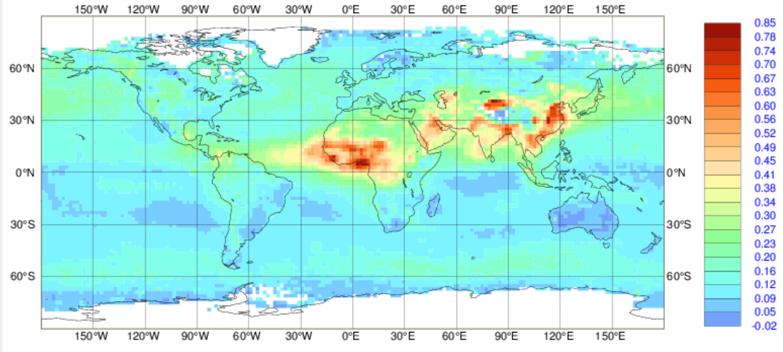
MODIS/Terra

MODIS/Aqua

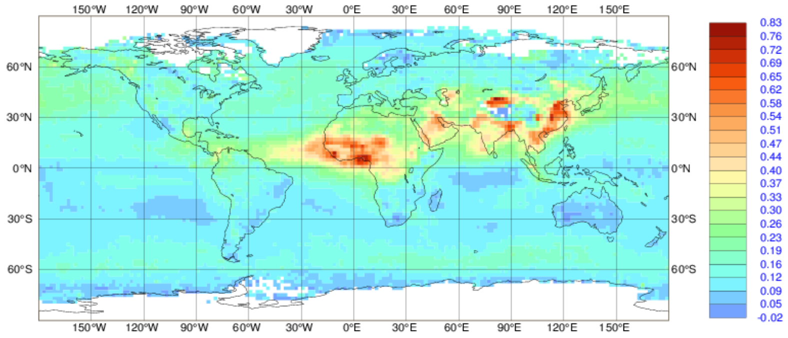
Results shown for PMAp V2.1 test data (1/2/2015-31/5/2015)

Impact on analysis model state

MODIS only



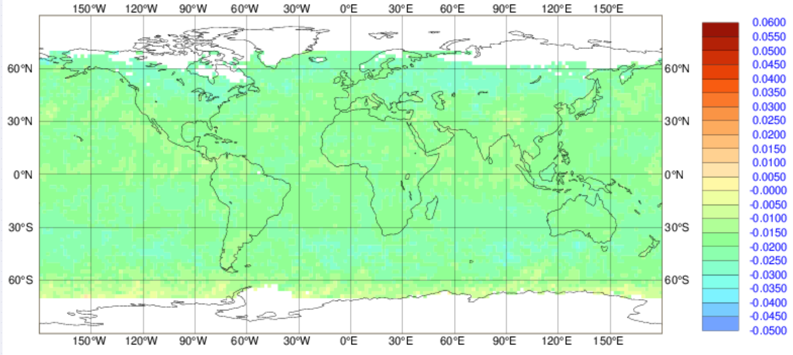
MODIS and PMAp



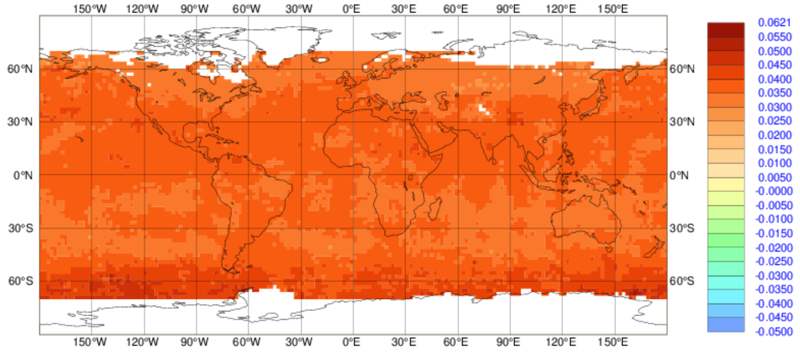
- Very similar mean model state for MODIS only and MODIS + PMAp

Bias correction fields

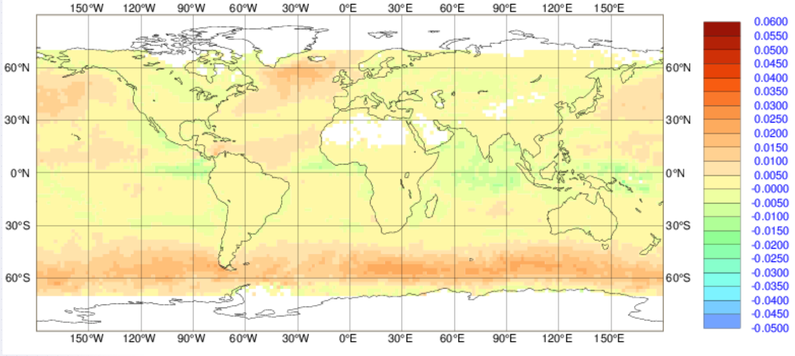
PMAp-A



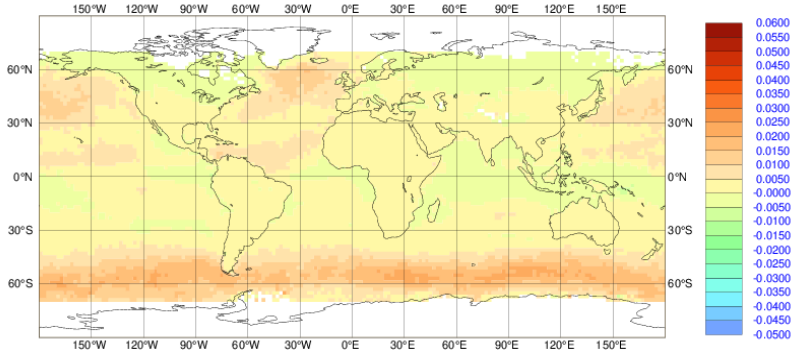
PMAp-B



MODIS/Terra



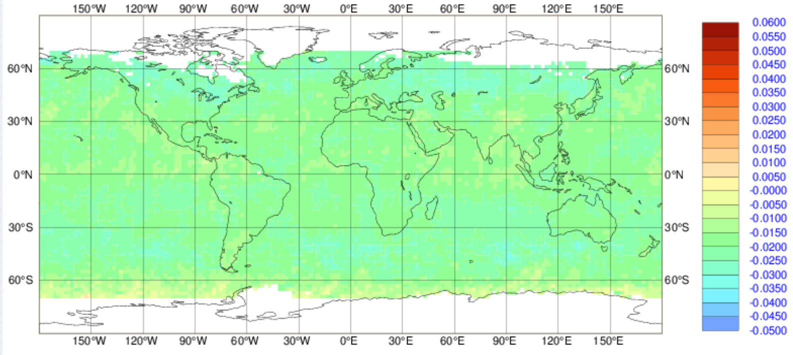
MODIS/Aqua



Atmosphere
Monitoring

Bias correction fields

PMAp-A



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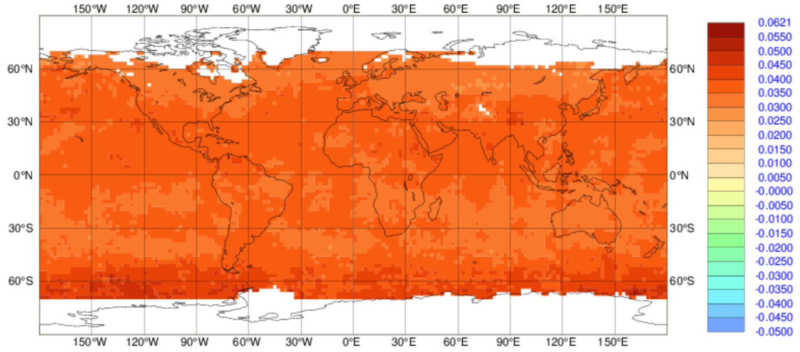
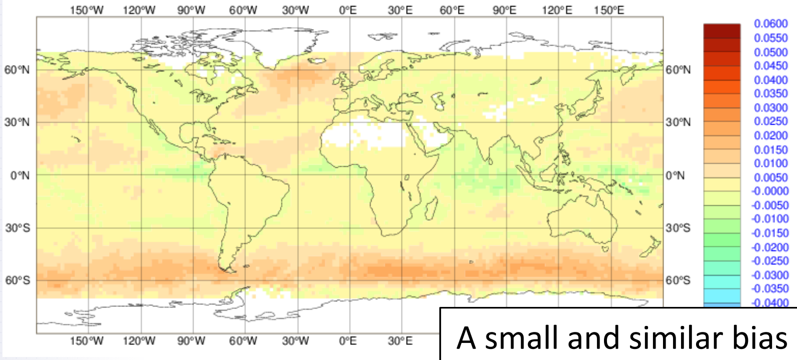
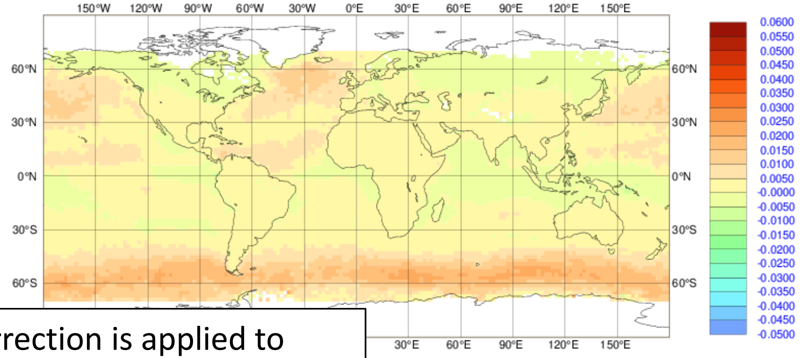


MODIS/Terra



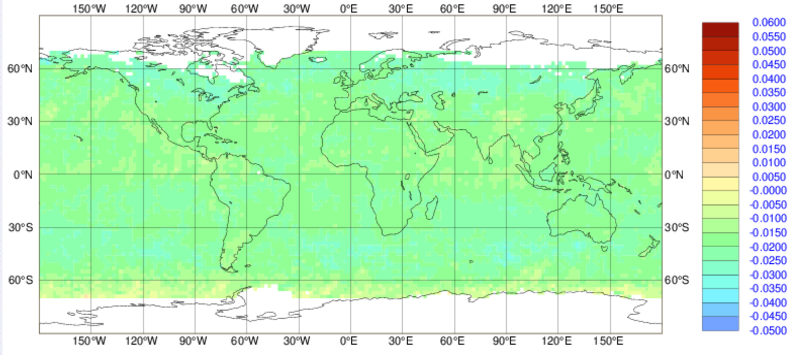
MODIS/Aqua



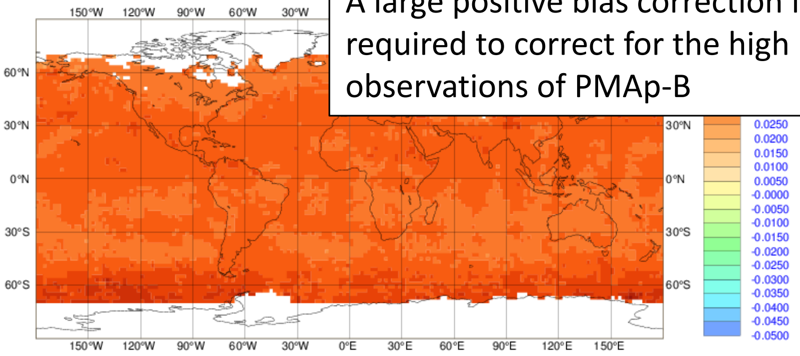
A small and similar bias correction is applied to both MODIS/Aqua and MODIS/Terra that accounts for the known difficulties with collection 5 data over the Southern ocean

Bias correction fields

PMAp-A

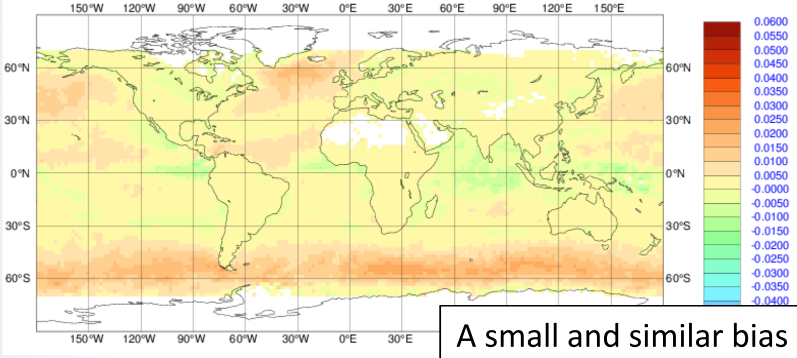


PMAp-B

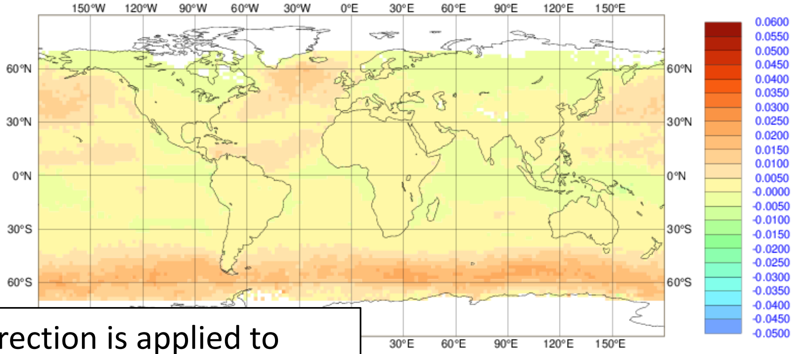


A large positive bias correction is required to correct for the high observations of PMAp-B

MODIS/Terra



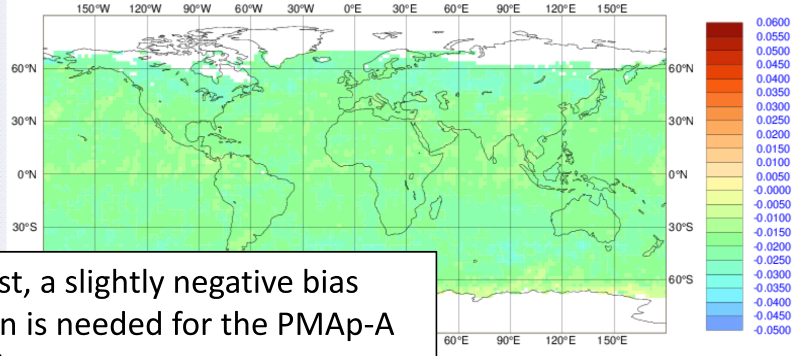
MODIS/Aqua



A small and similar bias correction is applied to both MODIS/Aqua and MODIS/Terra that accounts for the known difficulties with collection 5 data over the Southern ocean

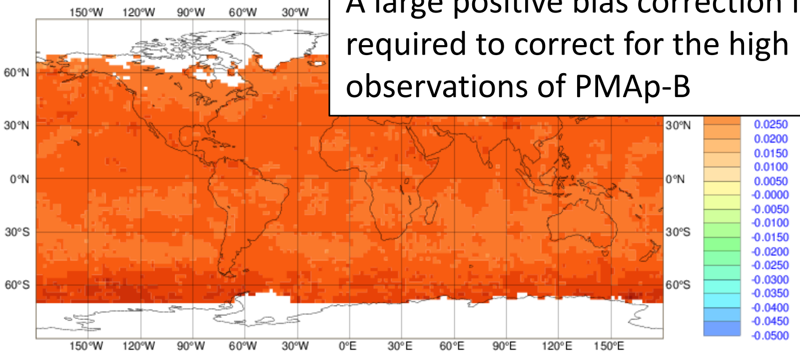
Bias correction fields

PMAp-A



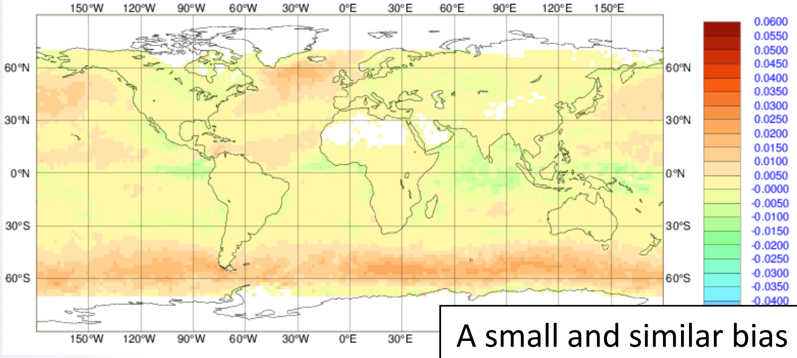
In contrast, a slightly negative bias correction is needed for the PMAp-A observations

PMAp-B

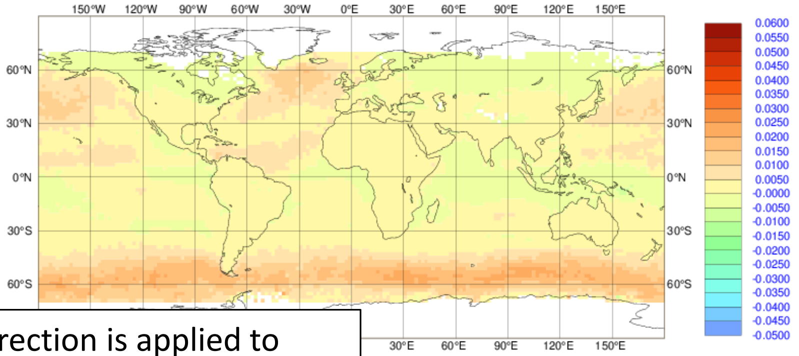


A large positive bias correction is required to correct for the high observations of PMAp-B

MODIS/Terra



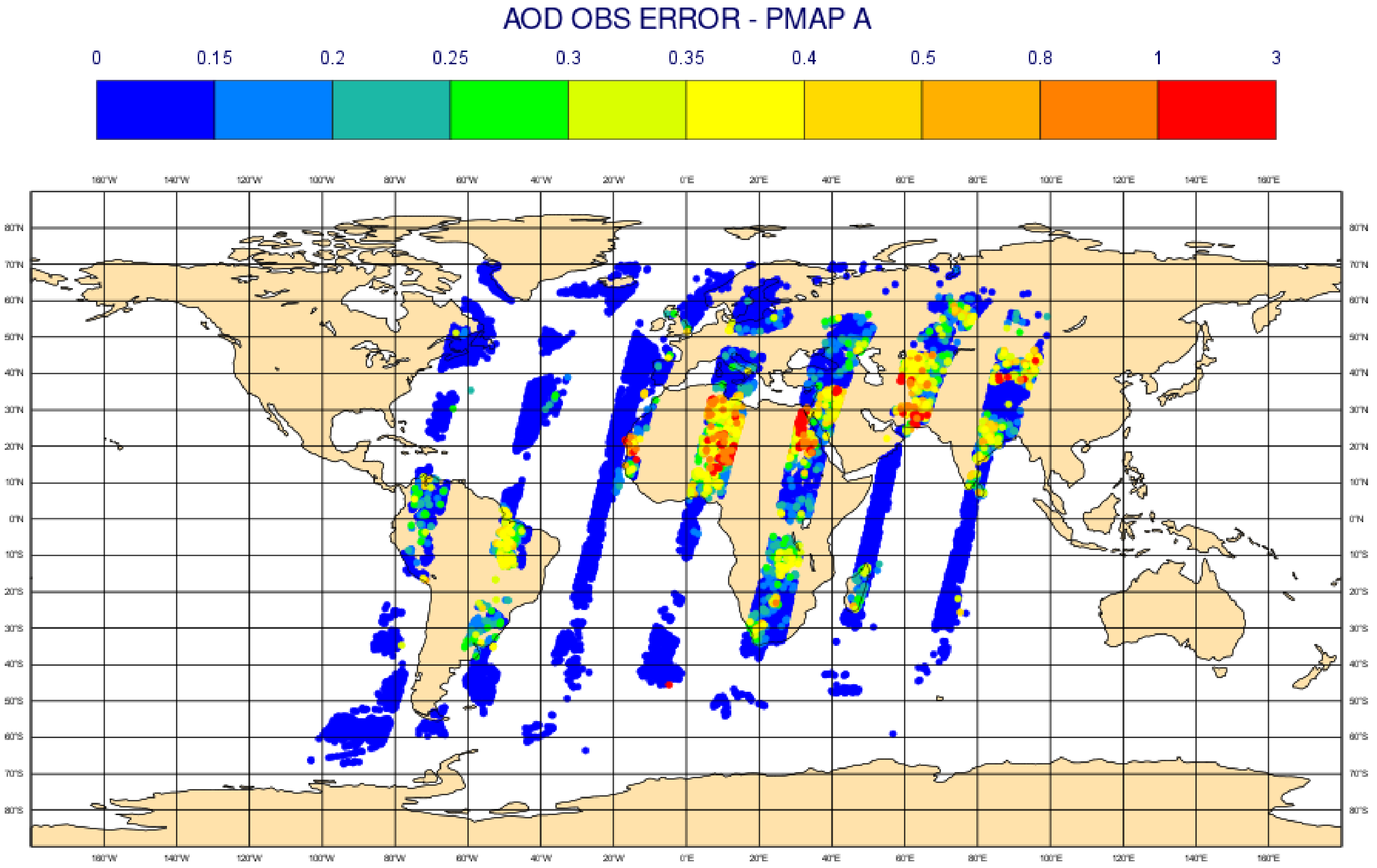
MODIS/Aqua



A small and similar bias correction is applied to both MODIS/Aqua and MODIS/Terra that accounts for the known difficulties with collection 5 data over the Southern ocean

Atmosphere Monitoring

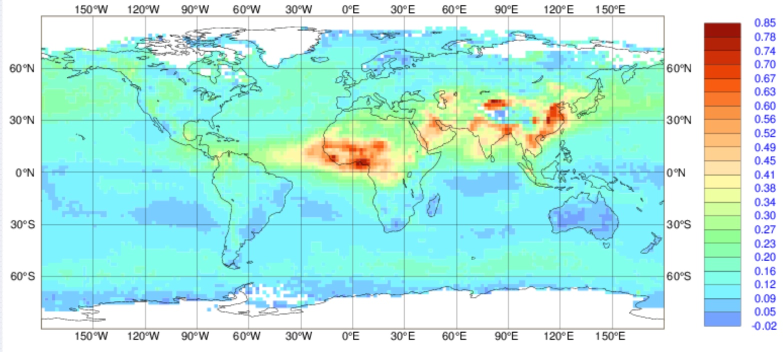
PMAp observation error



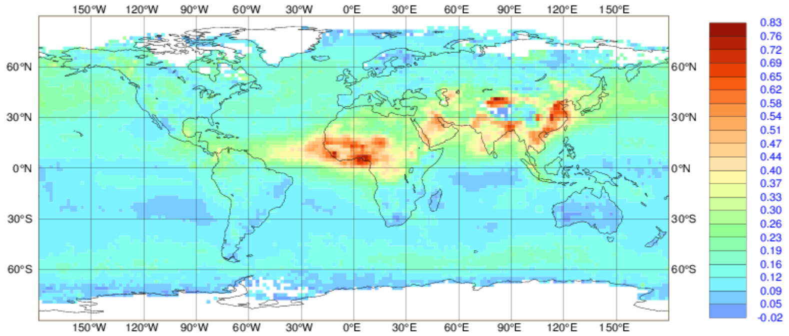
ECMWF Copernicus Europe's eyes on Earth European Commission

What happens if we only use PMAp?

MODIS only



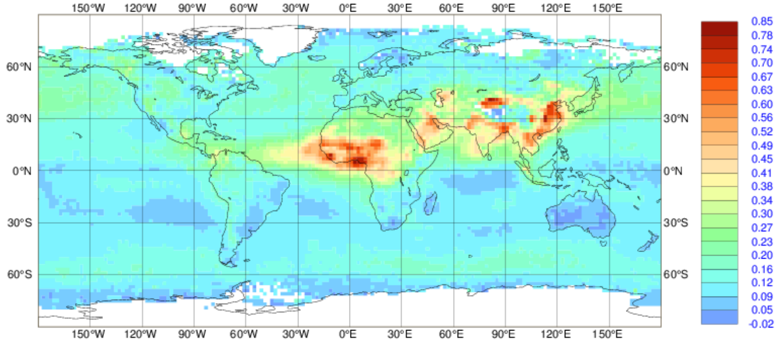
MODIS and PMAp



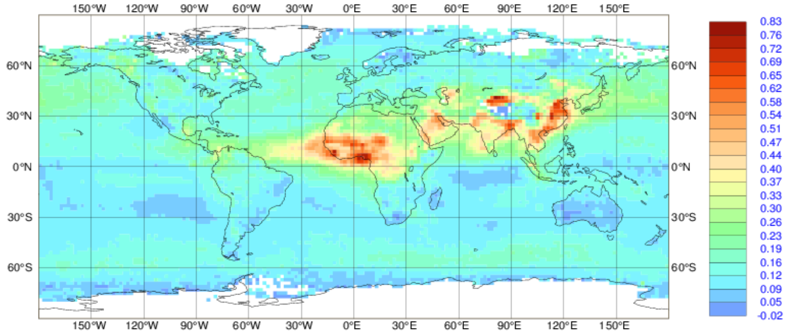
- Very similar mean model state for MODIS only and MODIS + PMAp

What happens if we only use PMAp?

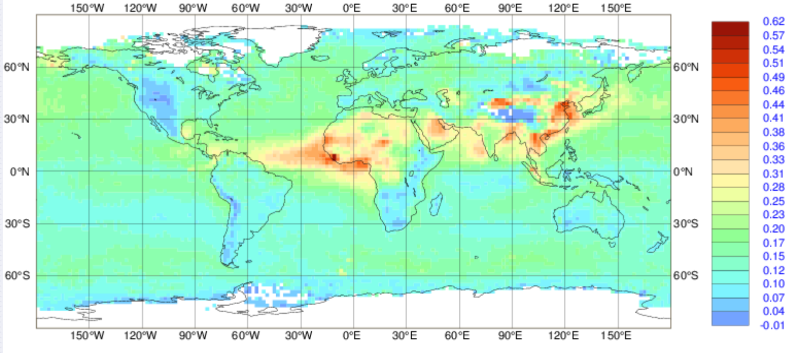
MODIS only



MODIS and PMAp



PMAp only

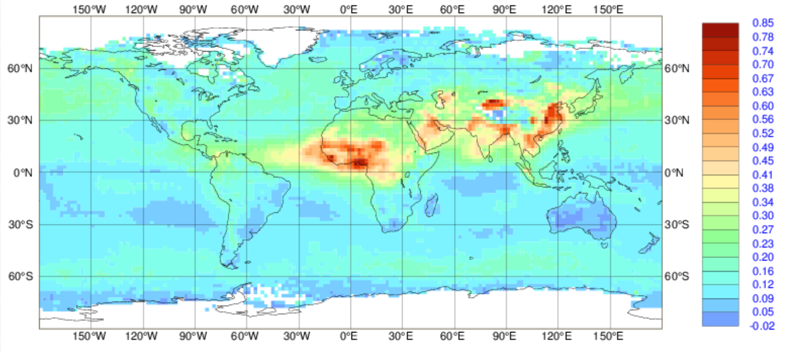


- Very similar mean model state for MODIS only and MODIS + PMAp
- Effect of higher PMAp-B observations apparent for PMAp only

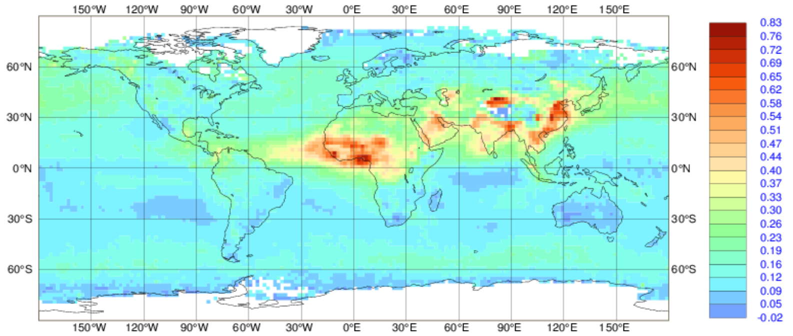
Atmosphere Monitoring

What happens if we only use PMAp?

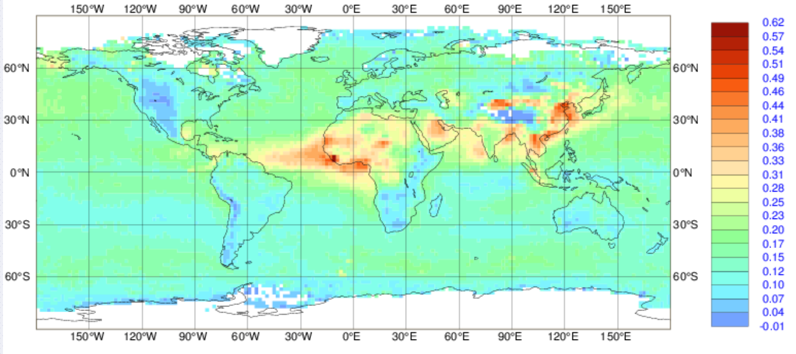
MODIS only



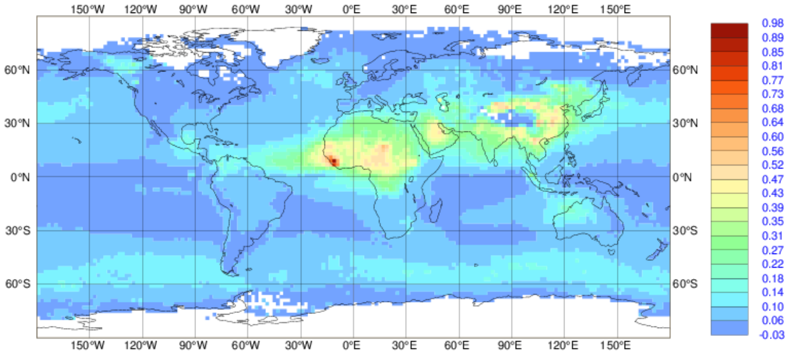
MODIS and PMAp



PMAp only



No AOD



- Very similar mean model state for MODIS only and MODIS + PMAp
- Effect of higher PMAp-B observations apparent for PMAp only
- PMAp only better than no AOD observations

Atmosphere Monitoring

Ongoing and Future Work

I. Data Assimilation methodology

- Work planned to incorporate the GLOMAP model in to the data assimilation system
- Work to make the LIDAR data assimilation operational (Angela Benedetti and Julie Letertre-Danczak)
- Assimilation of aerosol radiances (Angela Benedetti and Julie Letertre-Danczak)

II. Assimilated Observations

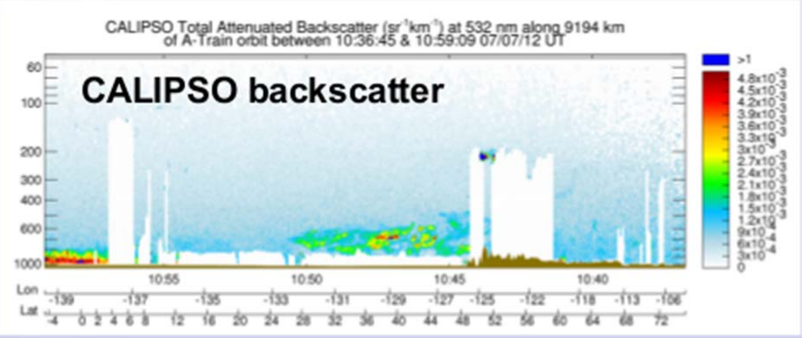
A. AOD retrieval observations

- Sentinel 3 – ideally by the end of the year
- VIIRS – work in progress
- SEVERI – Although EUMETSAT do not plan to provide a NRT AOD product , other groups are looking at this.

ECMWF Copernicus Europe's eyes on Earth European Commission

Future and Ongoing Work

B. Backscatter observations



- CALIPSO and Aeolus satellite LIDAR data (Angela Benedetti)

- A first attempt of assimilation for ground based LIDAR has been done for EARLINET data (July 2012) – work in progress
- Ground-based observations will be used as anchor to correct satellite lidar data from CALIPSO in the variational bias correction (varBC) framework.

(Julie Letertre-Danczak)

Atmosphere
Monitoring

Paper on CAMS aerosol system

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 114, D06206, doi:10.1029/2008JD011235, 2009

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Aerosol analysis and forecast in the European Centre for Medium-Range Weather Forecasts Integrated Forecast System: Forward modeling

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A. Benedetti,[1] A. Bonet,[1] J. W. Kaiser,[1] M. Razinger,[1] M. Schulz,[3] S. Serrar,[1]
A. J. Simmons,[1] M. Sofiev,[4] M. Suttie,[1] A. M. Tompkins,[1,5] and A. Untch[1]

Received 3 October 2008; revised 9 January 2009; accepted 21 January 2009; published 25 March 2009.

[1] This paper presents the aerosol modeling now part of the ECMWF Integrated Forecasting System (IFS). It includes new prognostic variables for the mass of sea salt, dust, organic matter and black carbon, and sulphate aerosols, interactive with both the dynamics and the physics of the model. It details the various parameterizations used in the IFS to account for the presence of tropospheric aerosols. Details are given of the various formulations and data sets for the sources of the different aerosols and of the parameterizations describing their sinks. Comparisons of monthly mean and daily aerosol quantities like optical depths against satellite and surface observations are presented. The capability of the forecast model to simulate aerosol events is illustrated through comparisons of dust plume events. The ECMWF IFS provides a good description of the horizontal distribution and temporal variability of the main aerosol types. The forecast-only model described here generally gives the total aerosol optical depth within 0.12 of the relevant observations and can therefore provide the background trajectory information for the aerosol assimilation system described in part 2 of this paper.

Citation: Morcrette, J.-J., et al. (2009), Aerosol analysis and forecast in the European Centre for Medium-Range Weather Forecasts Integrated Forecast System: Forward modeling, *J. Geophys. Res.*, 114, D06206, doi:10.1029/2008JD011235.

1. Introduction

[2] In April 1989, the ECMWF model was the first operational forecast model to include the effects of aerosols as part of its radiation transfer calculations (from the initial work of *Tanré et al.* [1984] in a climate version of the model). Since then, a revised aerosol climatology [*Tegen et al.*, 1997] was introduced in October 2003, and various studies [*Tompkins et al.*, 2005; *Rodwell*, 2005] showed the positive impact of this change on various aspects of the model, sometimes far from the location of the main change in aerosol optical thickness.

[3] As part of the project Global and regional Earth-system Monitoring using Satellite and in situ data (GEMS) [*Hollingsworth et al.*, 2008], the European Centre for Medium-Range Weather Forecasts (ECMWF) is developing its assimilation system to include observations pertaining to greenhouse gases, reactive gases and aerosols. For the computation of the trajectory forecast used in the assimilation, the Integrated Forecast System (IFS) has been extended to include a number of tracers, which are advected by the model dynamics and interact with the various physical processes. With respect to the aerosols, sources have thus been added to the model, and a representation of the aerosol physical processes (namely the interactions of the aerosols with the vertical diffusion and the convection, plus the sedimentation, dry deposition and wet deposition by large-scale and convective precipitation) are now part of the package of physical parametrizations of the ECMWF IFS model. A prognostic representation of aerosols is a feature of numerous climate models (see *Schulz et al.* [2006], *Textor et al.* [2006, 2007], and *Kinne et al.* [2006] for reviews of how various aspects of aerosol physics are represented in recent general circulation models). However, it is more of a novelty in global weather forecast models, given the requirements on the assimilation system to deal properly with the aerosol-relevant observations and the time constraint for producing an analysis and subsequent forecast in a near-real-time environment. As part of the GEMS project, aerosol-related observations (i.e., either aerosol optical depth retrievals or more directly, aerosol-sensitive radiances) will be assimilated together with all the other observations in a fully interactive way (A. Benedetti et al., Aerosol analysis and forecast in the ECMWF Integrated Forecast System: 2. Data assimilation, submitted to *Journal of Geophysical Research*, 2009).

---

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[4] Air Quality Research, Finnish Meteorological Institute, Helsinki, Finland.
[5] Now at Earth System Physics, International Centre for Theoretical Physics, Trieste, Italy.

0148-0227/09/2008JD011235$09.00

Atmosphere
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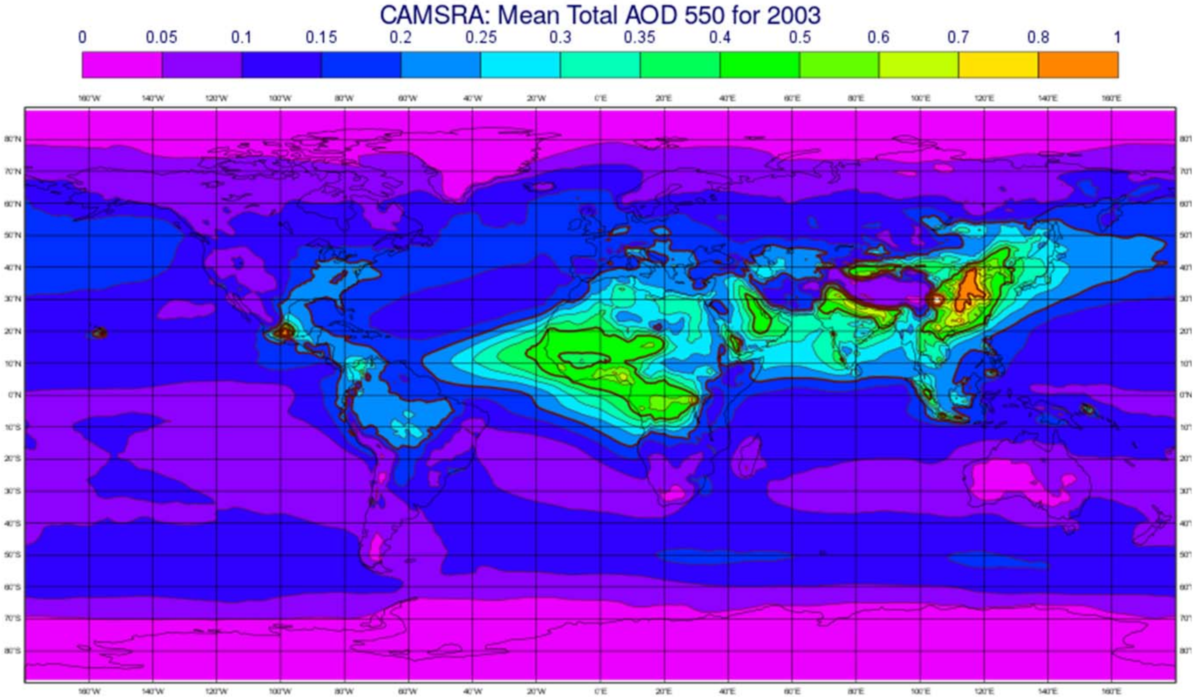
CAMS Reanalysis



- New reanalysis currently in the process of being produced by CAMS
- Will cover the period 2003-current day
- First data will be released in Autumn 2017
- Current aim is to have full data released in early 2018

Atmosphere Monitoring

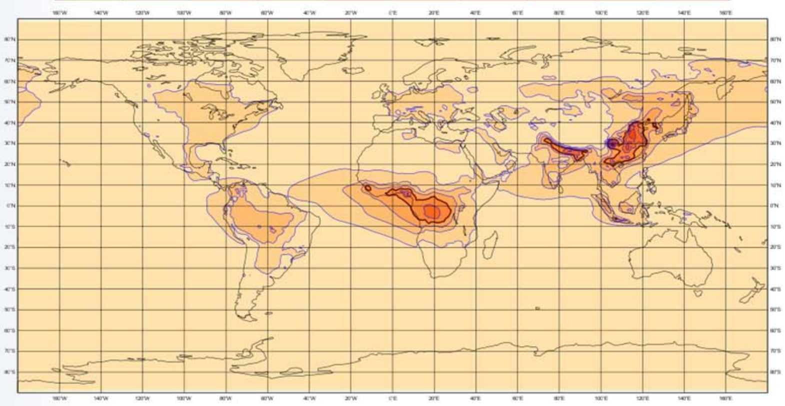
CAMS Reanalysis

Model changes	Observation streams
1. New aerosol optical properties for organic matter and sulphate 2. Debug of dust and sea-salt sedimentation 3. Decrease of the fraction of sea-salt aerosol subject to in-cloud scavenging 4. SO2 dry deposition velocities from SUMO 5. SOA production scaled on non biomass burning CO emissions 6. SO2 to SO4 conversion made more complex 7. SO2 to SO4 conversion e-folding time decreased 8. SO4 dry deposition velocity increased over the oceans 9. Scaling of biomass-burning BC emissions	1. MODIS collection 6 2. AATSR (when available)

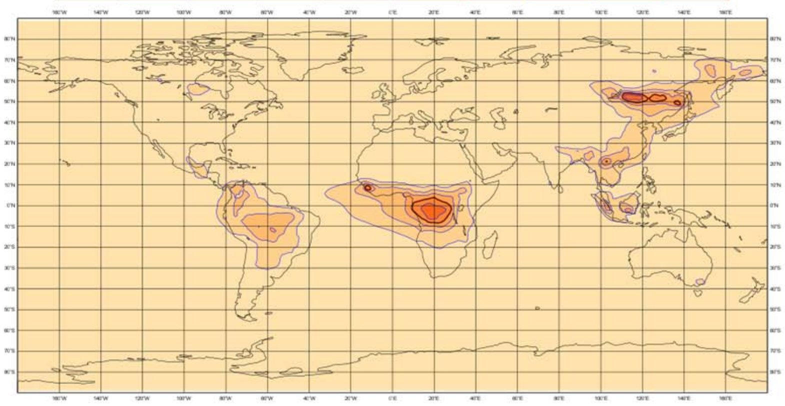
Atmosphere
Monitoring

Organic Matter AOD – 2003 mean

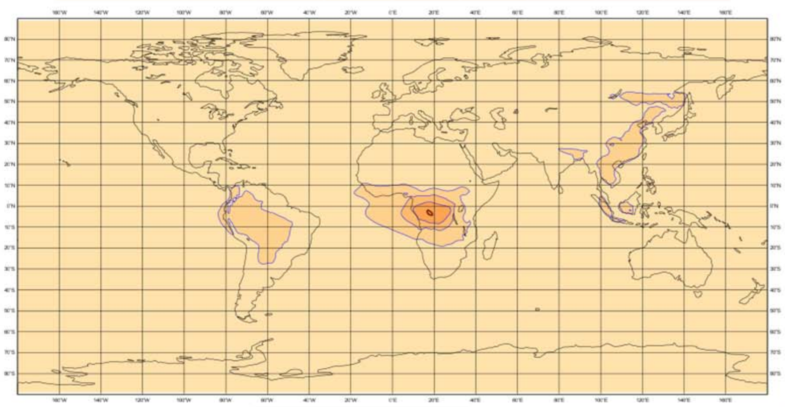
CAMSRA: Mean Organic Matter AOD 550 for 2003



CAMSiRA: Mean Organic Matter AOD 550 for 2003



MACCRA: Mean Organic Matter AOD 550 for 2003

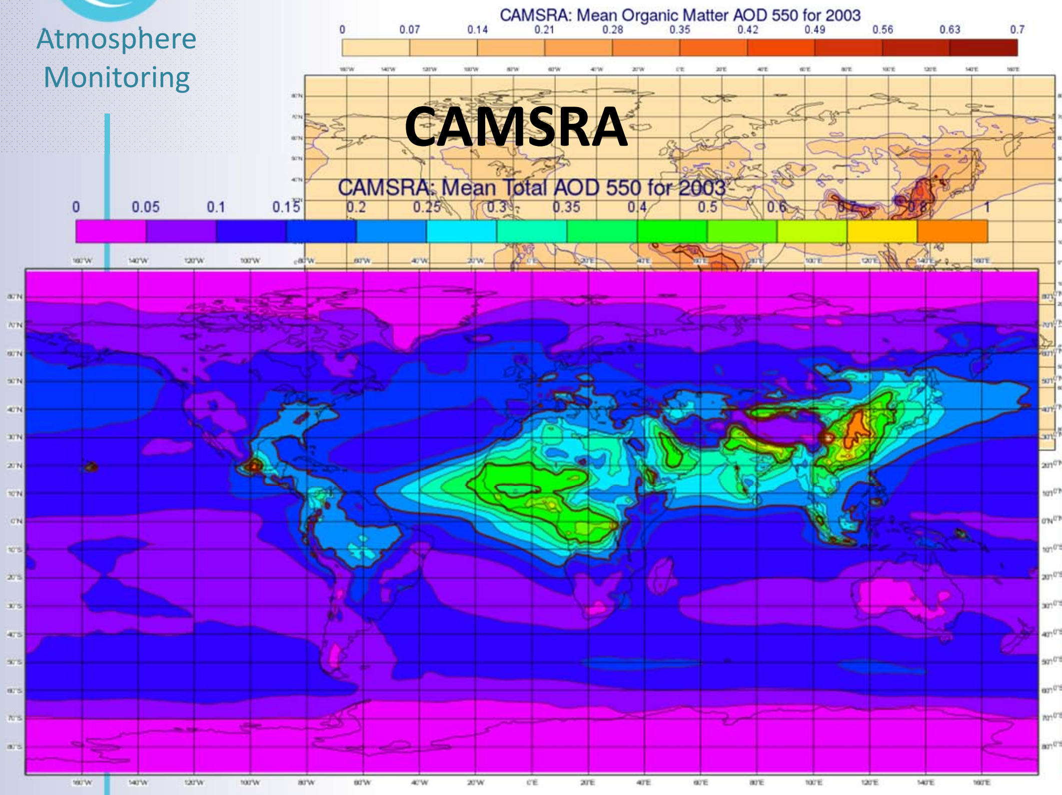


SOA production scaled on non biomass burning CO emissions

=> More organic matter in the system

Atmosphere
Monitoring

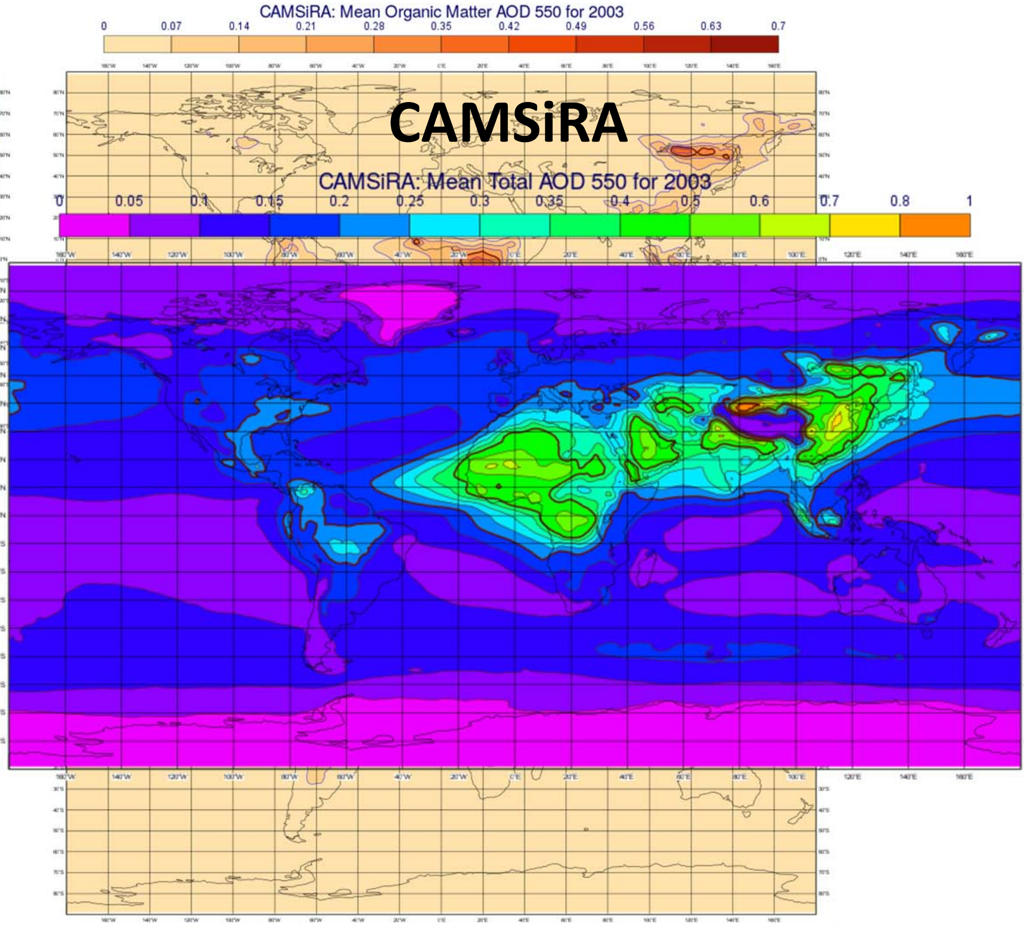
Organic Matter AOD – 2003 mean



CAMSRA

CAMSRA: Mean Organic Matter AOD 550 for 2003

CAMSRA: Mean Total AOD 550 for 2003



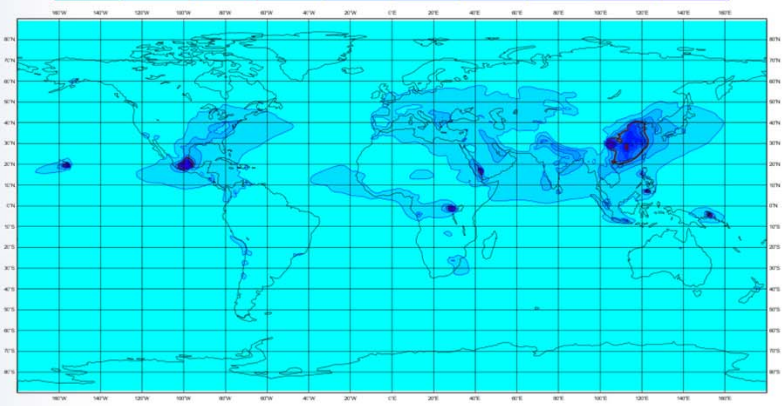
CAMSiRA

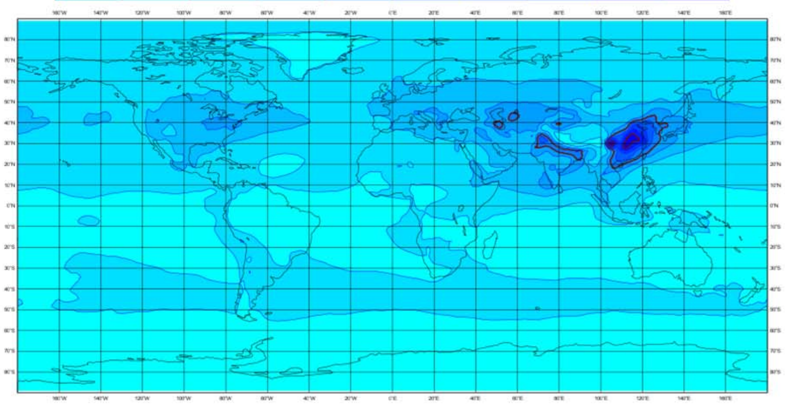
CAMSiRA: Mean Organic Matter AOD 550 for 2003

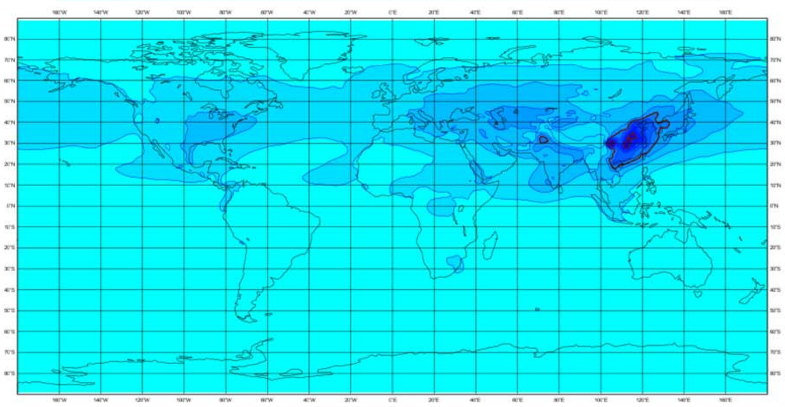
CAMSiRA: Mean Total AOD 550 for 2003

Atmosphere Monitoring

Sulphate AOD – 2003 mean

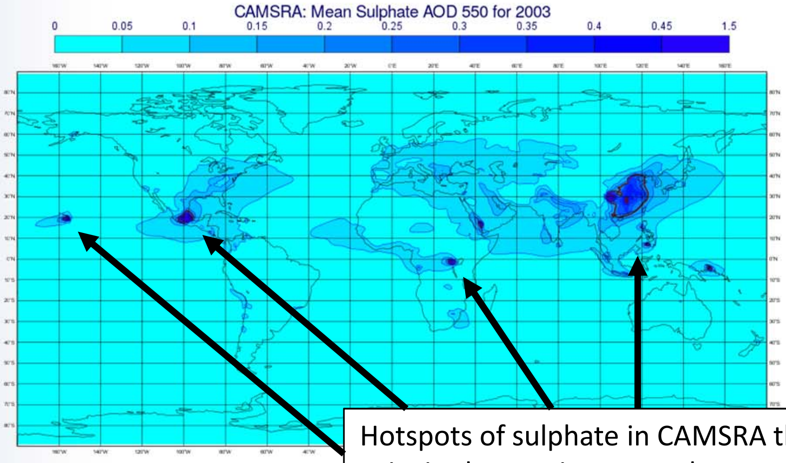

CAMSRA: Mean Sulphate AOD 550 for 2003

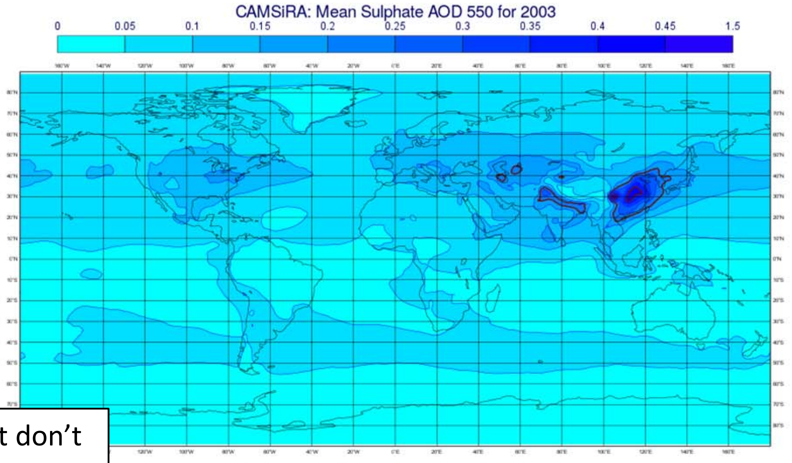

CAMSiRA: Mean Sulphate AOD 550 for 2003


MACCRA: Mean Sulphate AOD 550 for 2003

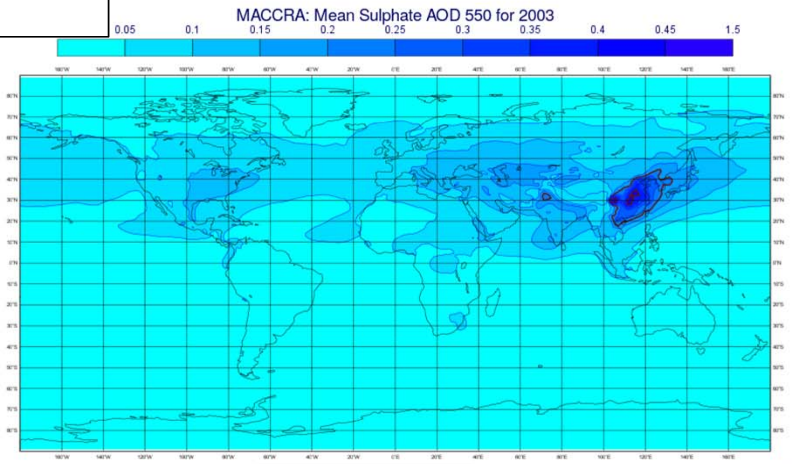
Decrease in sulphate to compensate for the increase in organic matter

Sulphate AOD – 2003 mean


CAMSRA: Mean Sulphate AOD 550 for 2003


CAMSiRA: Mean Sulphate AOD 550 for 2003

Hotspots of sulphate in CAMSRA that don't exist in the previous reanalyses


MACCRA: Mean Sulphate AOD 550 for 2003

Decrease in sulphate to compensate for the increase in organic matter

CAMS Reanalysis

Model changes

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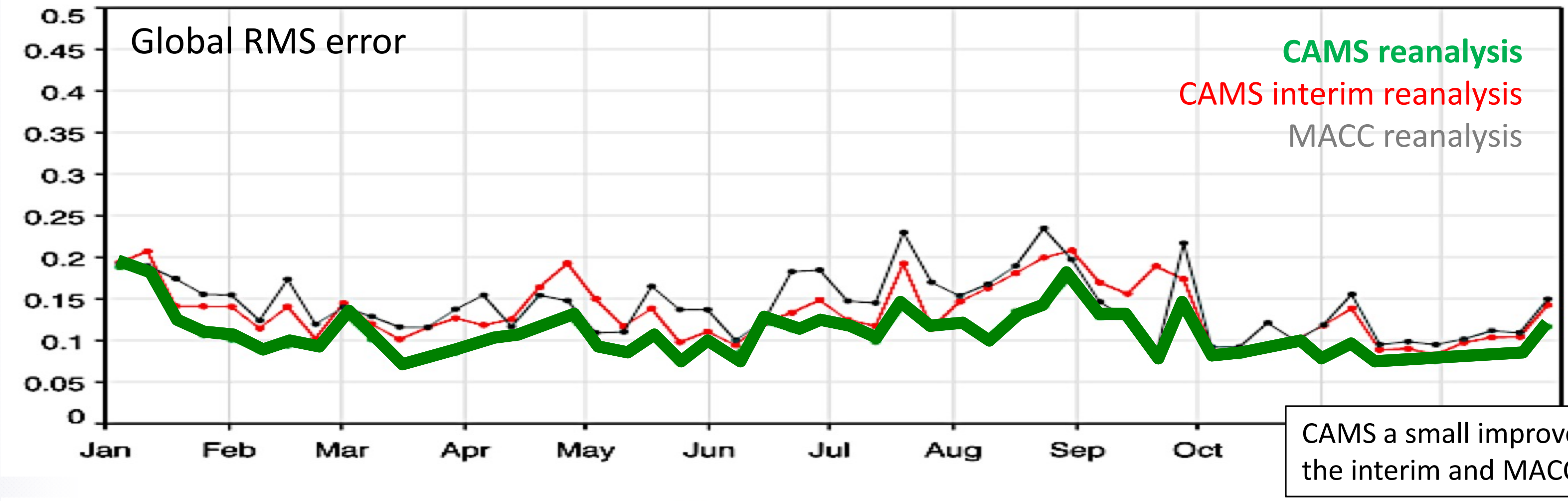
9. Scaling of biomass-burning BC emissions

Observation streams

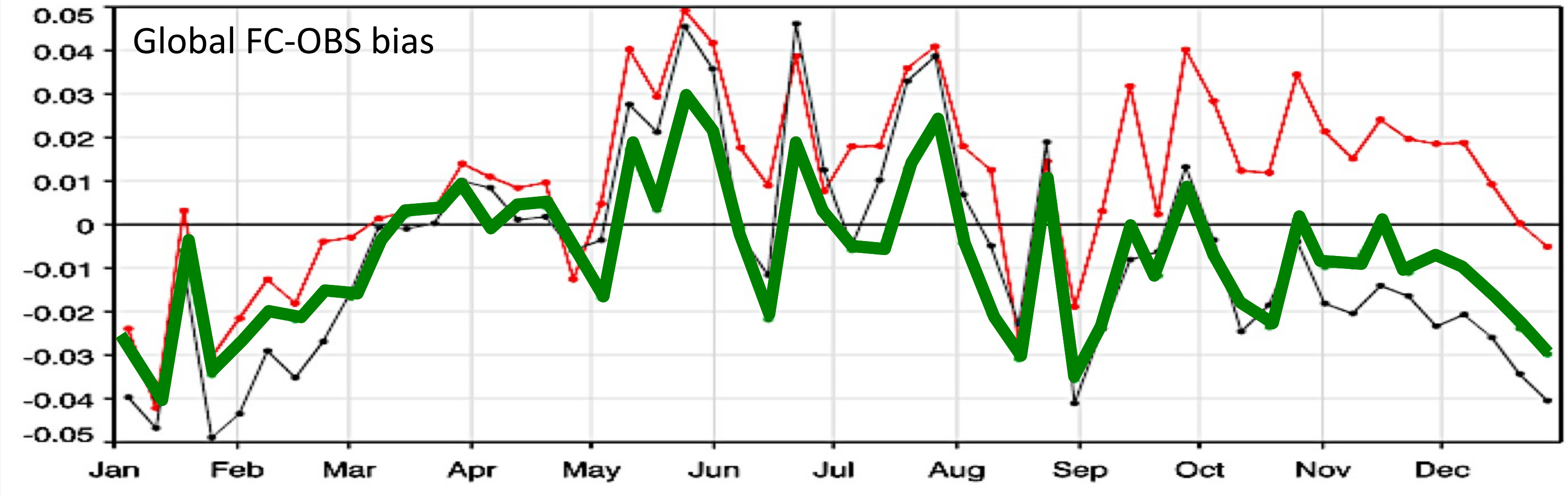
1. MODIS collection 6
2. AATSR (when available)

Atmosphere
Monitoring

Aeronet verification of Reanalysis - 2005



CAMS a small improvement over the interim and MACC reanalysis



Thank you.